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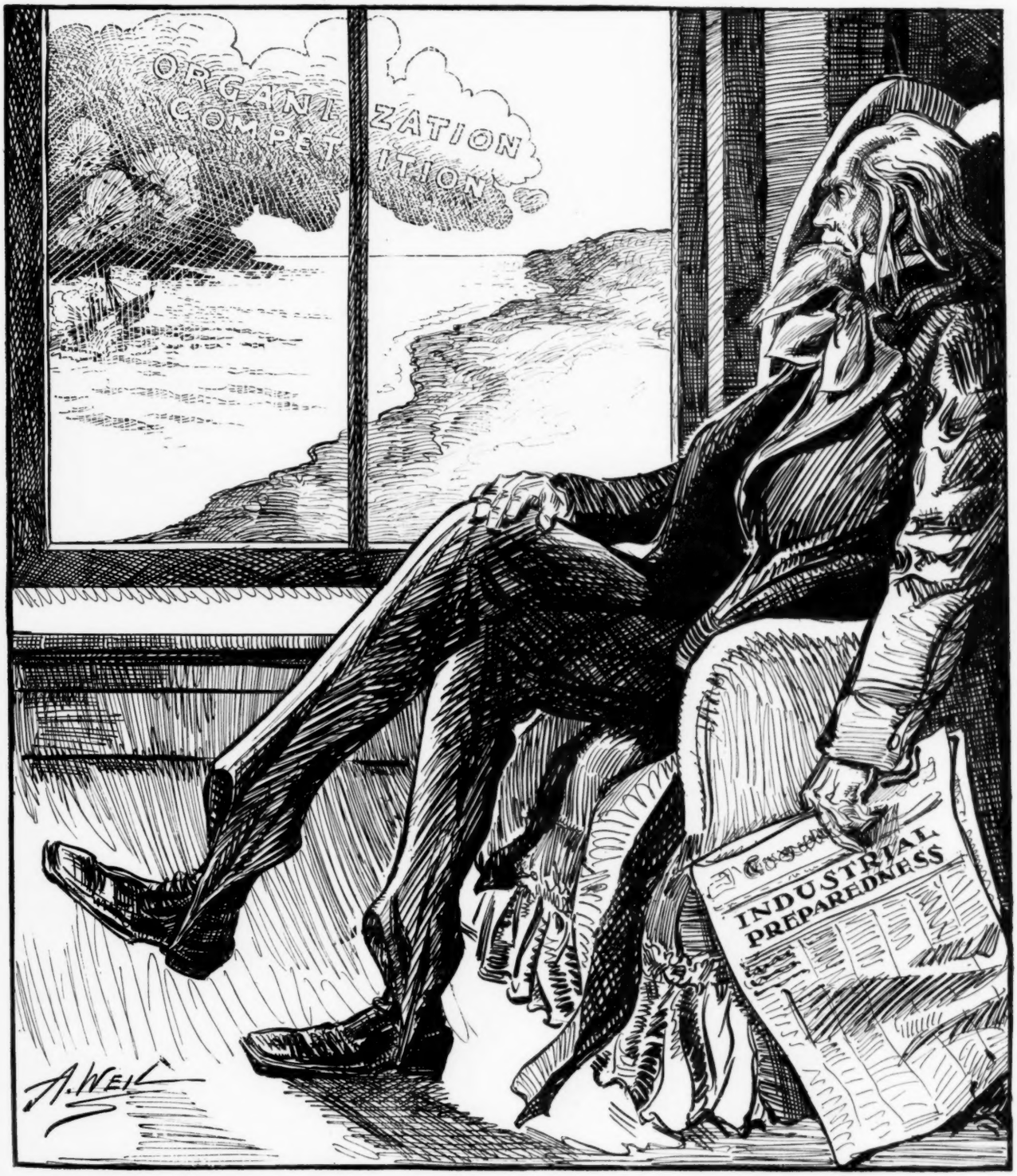

Can We Meet It?

Year's Review of the Power Field

During the last year engineering progress has been comparatively limited. In the phraseology of the trade the manufacturers have been "making hay," bending all their energies to keep up with a great bulk of orders under adverse labor conditions and difficulties met in obtaining raw materials.

An advance has been made in the size of the steam turbine. To keep pace, condensers have been improved and enlarged and boilers in larger units are being installed. There is a persistent tendency toward higher steam pressures and greater evaporation per square foot of heating surface. Several installations which will generate steam at 350 pounds pressure are under way, and pressures of 500 up to 1,000 pounds are being considered. Driving auxiliaries electrically has widened the field for the economizer, and a realization of the importance of boiler-room instruments, followed by their installation, has improved combustion efficiency. There has been some advance in stoker design and improvements in other auxiliary equipment. All this is of the greatest importance when the recent high prices of coal and the possibility that the cost in the future will remain above normal are considered.

Lower Power-Plant Buildings

In the design of power-plant buildings there is a tendency to break away from the enormous heights above ground and depths below, necessitating the use of great quantities of steel. The use of five to six pounds of structural steel per pound of steam-generating capacity is excessive when compared to a ratio of one to one prevalent in Europe. The placing of economizers over boilers and of the stacks over the economizers and the installation of overhead coal bunkers of large capacity were the factors leading up to the tall design. Making the economizer an integral part of the boiler, as has been done at the Ford plant, and decreasing the size of the coal bunkers by installing simple and dependable coal-handling machinery will reduce this exorbitant use of steel and result in a gradual lowering of power-plant buildings.

Notable Steam Plants Completed

Of the notable steam-power stations completed during the year, the Essex plant of the Public Service Electric Co. of New Jersey is of particular interest. This plant now has a capacity of 50,000 kilovolt-amperes in two units, and in 1917 a 35,000 kilovolt-ampere turbo-generator will be added. The layout, arranged on the unit plan, provides for an ultimate capacity of 200,000 kilovolt-amperes. Both electrical and steam systems are unusually simple and flexible, and the plant cost per unit of capacity is the lowest on record. Following modern tendencies, the boiler room is replete with intruments and gages, all valves are electrically operated from the boiler-room floor and a three-panel switchboard mounting draft and temperature gages and devices for controlling the draft and stoker equipment serves each boiler. The steam generators are cross-drum boilers having 13,723 square feet of heating surface. They are equipped with sixteen-retort stokers reported to be the largest in service. Electric-driven auxiliaries make economizers profitable, and forced, natural or induced draft is available for individual or collective use. On the electrical end the use of instruments has been profuse, the air cooling the generators is conducted into the forced-draft fanroom and the exciter system is the most complete ever devised. Three separate sources of excitation are provided, and the transfer from one to the other is made automatically.

A smaller plant typical of modern development is that of the Public Service Company of Northern Illinois, now being erected near Joliet, Ill. Cross-drum boilers with a heating surface of 10,000 square feet will generate steam at 350 pounds' gage pressure. A superheat of 225 degrees Fahrenheit will raise the final temperature of the steam to 660 degrees. Two stokers of the chain-grate type will serve each boiler, the ratio of grate area to boiler heating surface being 1 to 43—one of the highest in the Middle West. As the only auxiliaries in the plant to be steam-driven are the multiple-stage boiler-feed pumps, economizers were provided. These were placed above the boilers, but form an integral part of the heating surface. Turbines designed for a working pressure of 300 pounds is a step in advance of hitherto best practice in stationary plants, although designs are now being perfected for pressures as high as 500 pounds.

The new plant of the Ohio State Power Co., near Fremont, is another modern installation completed during the year. The boiler pressure is 250 pounds. To replace the usual atmospheric exhaust, the turbines are provided with vacuum-controlled throttling valves that shut off the steam supply when the vacuum drops to eight inches. Turbines driving the boiler-feed pumps and condenser auxiliaries are of new design, operating on less than thirty pounds of steam per brake horsepower-hour, supplied at 250 pounds pressure and 125 degree of superheat. The piping is special and the construction all the way through uniformly good.

Notable Plants in Detroit

At Detroit the Ford plant is still under construction. With its immense gas-steam units, methods of recovering waste heat and the large water-tube boilers now under erection, the plant is unique. Surrounding the producer-gas engine with every advantage possible should once and for all determine the status of this type of prime mover.

Connors Creek plant of the Detroit Edison Co., given prominent mention in last year's review, is being enlarged. At the Northwest Station of the Commonwealth Edison Co. the work of erecting the three additional 30,000-kilowatt turbines to complete the station and their corresponding batteries of boilers is under way. One more unit of the same size and a 35,000-kilowatt machine are on order for Fisk Street Station. The Indianapolis Light and Heat Co. is erecting a new station in which it is proposed to place eventually six 18,000-kilowatt turbo-generators. The boilers will be served by chain-grate stokers and operate at a pressure of 250 pounds. At Windsor, fifteen miles from Wheeling, W. Va., work has begun on a new steam plant to contain six 30,000-kilowatt turbine-driven generators, although present plans call for only two units. Only large consumers of energy will be served. It is proposed to build a 130,-

000-volt transmission line to Canton and a 66,000-volt line connecting into the distributing system of Wheeling. The Union Gas and Electric Co., of Cincinnati, is to build a 50,000-kilowatt plant with provisions to enlarge it to 100,000 kilowatts. At Tonawanda the Buffalo General Electric Co. is building a 200,000-horsepower steam plant to be featured by high steam pressure and superheat and special valves and fittings to withstand the service. A plant designed for an ultimate capacity of 105,000 kilowatts has been authorized by the Dayton Power and Light Co., and two 15,000 kilowatt sets are now being installed.

Many smaller plants have been built during the year and additions have been made to existing plants. Conditions have been unusually active in this field to meet the excessive demands for power made by manufacturing interests.

Some Large Units

In addition to the new plants just enumerated there have been a number of single installations of machines or apparatus worthy of mention. The Inland Steel Co. at Indiana Harbor has installed a 15,000-horsepower Westinghouse direct-current motor, the largest of its kind, to drive a 40-inch reversing blooming mill. It receives its power and is controlled from a flywheel motor-generator set, so that the power from the line will be equalized to practically a constant load. To meet the demands of increased business, the Naragansett Electric Lighting Co., of Providence, R. I., has contracted for a Westinghouse cross-compound 45,000-kilowatt turbine at 95 per cent. power factor. The high-pressure element is of the single-flow straight reaction type, and the low-pressure end is designed on the double-flow principle, with eight groups of blades on either side and each side exhausting into a separate condenser of the jet type. The condenser is of the Westinghouse-LeBlanc low-head design proportioned to handle 18,000,000 pounds of circulating water per hour and condense approximately 500,000 pounds of steam in the same time, when maintaining a vacuum of 28 inches with water at 70 degrees. It is the largest jet condenser yet constructed. What is believed to be the largest natural-draft cooling tower so far built has been erected recently by the Wheeler Condenser and Engineering Co. at the plant of the American Steel and Wire Co., Anderson, Ind. It is 150 feet long, 50 feet wide and 75 feet high, is equipped with two chimneys creating natural draft and has capacity to cool 7,300 gallons of water per minute from 115 to 85 degrees Fahrenheit. Other large equipments of the year, such as turbines and boilers, are mentioned elsewhere.

While the last twelve months have seen the inception of many new and modern plants, they have also witnessed the passing of one of the notable stations of its day—the Harrison Street plant of the Commonwealth-Edison Co., of Chicago. In its prime the station established a record for operating economy, and through the research work conducted on combustion, characteristics and values of coals, smokeless operation, etc., the plant became known as the laboratory of the central-station industry. During the summer months it was dismantled, the acetylene torch playing an important part in the work.

As previously stated, there is a decided trend toward larger sizes of steam turbines. Not many months ago 35,000 kilowatts in a single machine was considered the economical limit. The Detroit Edison Co. has recently ordered from the General Electric Co. a 50,000-kilovolt-ampere turbo-generator. It will be a single turbine of single-flow design directly connected to a single generator, and in one casing will develop more power than any turbine in the world. Its condenser will also be the largest on record—a single-pass condenser to have 70,000 square feet of surface and to be equipped with a circulating pump at either end requiring 450 horsepower to drive it.

Of still greater unit capacity, however, will be the two 60,000-kilowatt Westinghouse three-cylinder two-stage three-generator units on order by the Interborough Rapid Transit Co., of New York City. These units have one high-pressure element and a double-flow low-pressure turbine on either side. In reality the unit is made up of three separate machines. The individual elements may be operated separately, the low-pressure turbines alone, or the high-pressure and one low-pressure cylinder, so that the shutting down of one element need not disable the entire unit. While this is a flexible arrangement, it introduces complications over those encountered with the single machine and the cost is greater. On the other hand, the four paths offered to the steam from the high-pressure cylinder provide large areas for the great volume of low-pressure steam, thus tending to utilize to full advantage the steam in the lower stages and thereby increasing the economy of the unit.

Another large cross-compound unit is on order by the Narragansett Electric Lighting Co., of Providence, R. I. The machine drives two generators. The high-pressure element is single-flow and the low-pressure turbine double-flow. The capacity of the unit is 45,000 kilowatt. A number of large turbines rated at twenty, thirty and thirty-five thousand kilowatts are being erected or have been ordered during the year. Among them is a 35,000-kilowatt single-casing turbine for the Boston Elevated Railways Co. The steam guarantee on this unit, when developing 25,000 kilowatts, of 10.65 pounds per kilowatt-hour is interesting, as it is the lowest that has come to our attention, although it is unofficially reported that some of the large turbines, 30,000-kilowatts and over, have actually showed a steam performance closely approaching ten pounds per kilowatt-hour.

Large Turbines for Chicago

The greatest aggregate capacity in turbines on order at the present time must be credited to the Commonwealth-Edison Co. of Chicago. Five great machines, some of them now under erection, are being built for this company. Four are rated at 30,000 kilowatts and one at 35,000 kilowatts. As a matter of fact the 30,000-kilowatt machine now in service at the Northwest Station easily develops continuously 35,000 kilowatts, and more for short periods, so that the continuous generating capacity of the five units should easily reach 175,000 kilowatts.

The Dayton Power and Light Co. has installed one and is now erecting two more of the largest bleeder turbines in the world. The machines are rated at 7,500 kilowatts. After the first stage they are designed to deliver 80,000 pounds of steam per hour, the remainder of the steam, 90,000 pounds, passing through the other four stages to the condenser. Under these conditions each turbine will develop approximately 10,000 horsepower.

There has been considerable advance in the development of small and medium-sized turbines. Improvements in design have bettered economies and the installation of two nozzles, for light and heavy loads respectiveiy, has resulted in better economies on fractional loads. Great numbers of geared turbines have been built for the driving of direct-current generators and the propulsion of ships, the turbine in the latter case being geared directly to the propeller shaft. Extensive application of this type of unit has also been made to auxiliary equipment such as pumps, fans and exciters, the gears in each case allowing the most efficient speed for the machine in question and the high speed at which the turbine is most economical.

In the driving of condenser auxiliaries there is division of opinion between the turbine and the motor. The latter is more efficient, but its source of supply is perhaps less reliable and in the case of an interruption of service or starting up quickly to meet a sudden demand, there is apt to be delay in getting the auxiliary plant into operation. A stand-by supply such as a battery, independent of the main units, would relieve the situation, but in large plants where thousands of kilowatts are required by the auxiliaries, the battery would be out of the question. Here reliability is of prime importance, and for this reason turbines are gaining favor. Frequently a double drive is provided, the motor normally carrying the load, which in case of an interruption of the electric supply is automatically shifted to the turbine. More often, however, the choice between the two is determined by the heat balance, a sufficient number of turbines being operated to meet the demand for exhaust steam. When all the exhaust is utilized by the feed water, the turbine requires only about ten per cent. of the energy in the steam and under these conditions is more economical than the motor. The use of the double drive has also extended to exciter sets, affording, as before, a dual protection against interruption of service and providing a more flexible unit by which to maintain the heat balance of the station.

In condensers there have been improvements in features of detail, the goal being a uniform pressure within the shell and a minimum drop through the condenser. Reduction gearing, double drives or various combinations of the auxiliaries under one drive are features that vary with the installation. During the year an unusual number of large condensers were placed on order, the largest being a 70,000-square foot condenser for the Detroit Edison Co.

Steam Engines

Of steam engines there is little new to report. Poppet-valve and uniflow engines have invaded the refrigerating field, and the latter is finding favor in iron and steel mills. An interesting comparison presented during the year showed that for noncondensing operation or for vacuums up to 28 inches, in sizes up to 1,000 kilowatts, the uniflow engine was more economical than the the turbine. As a consequence it had a limited field in the steel-works power plant. When directly connected to the rolling mill, the uniflow engine has the advantage over the steam-turbine electric drive unless the steel mill is so large and the load such that turbo-generator units of over 8,000-kilowatt capacity can be installed. Its chief advantage over the turbine or the compound engine is its flat water-rate curve.

In Germany a number of uniflow engines have been installed for rolling-mill work, the largest on record having a maximum continuous capacity of 6,300 horsepower and a short-duration peak-load capacity of 8,000 horsepower. The average load is 4,000 horsepower. The engine drives a 30-inch three-high mill. In this country the first uniflow engines for rolling-mill work are under construction by the Nordberg Manufacturing Co. for the Youngstown Sheet and Tube Co. There will be two units, the larger having a steam cylinder 44x50-inches, a speed of 110 revolutions per minute and a capacity varying from 700 to between 3,000 and 4,000 horsepower. The smaller engine has a 37-inch cylinder and a stroke of 48 inches. The steam conditions will be approximately 170 pounds pressure, 75 degrees superheat and 20 inches vacuum in barometric jet condensers.

Internal Combustion Engines

Outside of a few isolated cases, such as the Ford plant and some additions to steel mill plants, the past year does not record much for the large gas engine. In smaller sizes, however, especially in the natural gas belt, a number of firms report very satisfactory business. The gas producer situation stands about as it did a year ago. It is possible, however, that the present coal prices may work to the advantage of the producer.

Big strides have been made during the past year in the oil engine field. Several additional firms, including three of our largest shipbuilding plants, have taken up Diesel engines, and most of those already building them have improved their shop facilities in anticipation of the greatly increased business which is now rapidly materializing. This demand is coming largely from the mining districts of the Southwest, pipe line pumping stations, mills and small central stations in the South, and refrigeration plants, although one finds the Diesel engine in such diversified service as flour mills and driving ventilating fans in railway tunnel work in Canada.

Several manufacturers of stationary medium-compression type oil engines are preparing to enter the marine field as well.

The popularity of the two-stroke-cycle engine, so marked a few years ago, seems to have waned, and the present outlook favors the four-stroke-cycle engine as the standard type of the future, although a few concerns are still pushing the two-stroke-cycle engine.

Steam Boilers and Explosions

A survey of several years back shows that the boiler unit is rapidly increasing in size. The average upper limit for large plants has jumped from 6,000 or 7,000 square feet of heating surface to 12,000 square feet, and in isolated cases such as at Delray and Connors Creek double this surface is utilized. At the plant of the Ford Motor Co. Badenhausen boilers having 25,000 square feet of heating surface are being erected. This includes a rear economizer section integral with the boiler proper, which contains nearly one-third of the surface. Including all surface inclosed by the setting, these boilers are the largest in this country and may be compared to a Siller-Christians boiler installed at the Reisholz Station of the Rheinisch-Westfälisches Elektrizitätswerk A. G. near Düsseldorf, Germany. This unit is claimed to be the largest in Europe, the boiler proper containing 29,600 square feet of heating surface. It

evaporates from 123,000 to 132,000 pounds of feed water per hour from 86 degrees Fahrenheit into steam at 220 pounds gage pressure and 600 degrees Fahrenheit. The highest rate shows an evaporation of less than 4.5 pounds per square foot of heating surface per hour. In this country an evaporation of ten pounds per unit of surface is not uncommon and sixteen pounds has been reached with small sacrifice in efficiency. The D. Connelly Boiler Co., of Cleveland, stands ready to supply boilers having 10,000 to 40,000 square feet of heating surface in the seven-drum design built for 300 pounds pressure, while the Badenhausen Co., of Philadelphia, claim to have designed boilers containing 45,000 square feet of surface.

Attention has been called previously to the tendency toward higher pressures and the more general use of boiler-room instruments. Among the latter may be mentioned the new Bailey steam and water meters, the Kennicott cycloid water meter and a blowoff recorder showing the number of times the boiler is blown down and the duration of the periods.

Recently wide attention has been given to the Talbot boiler, intended for marine use. It is of the contraflow type in which the water enters near the stack and leaves in the form of steam near the furnace. Forced circulation by means of a pump drives the water through the tubes at high velocity, a factor favoring a high rate of evaporation. The feed water and fuel burners are automatically controlled to meet widely varying demands for steam. As the boiler has no drums and is made up of tubes and headers of relatively small diameters, it will withstand high operating pressures.

Among the auxiliaries the wider range and more general use of the economizer is to be noticed. The tendency toward the built-in economizer, whereby it is made an integral part of the boiler, is illustrated by the Ford boiler and the installation of the Public Service Company of Northern Illinois near Joliet. A new underfeed stoker, the Moloch, has been recently announced, and work is progressing on a forced-draft chain-grate stoker.

For the year ended June 30, 1916 *Power's* tabulated record shows 333 boiler failures, which killed 147 and injured 377. The property damage, which was not even estimated in many cases, totaled nearly one-half million dollars, or about $1,500 per accident. The causes assigned attribute 60 failures to cast-iron headers, 39 to ruptured tubes, 36 to low water, 16 to high-pressure and 90 to cast-iron water and steam heaters.

Boiler Legislation

Little progress has been made during the year in securing engineers' license and boiler-inspection laws. This was partly due to the fact that there were few states in which the legislatures met. Rhode Island introduced a bill, but it was defeated. Activity was reported in Washington, Wisconsin, Maryland and Colorado. The American Society of Mechanical Engineers Code dealing with boiler construction is receiving widespread attention. Its general adoption is being urged by the American Uniform Boiler Law Society. During the year Pennsylvania and California adopted the Code, following the example of a number of other states. The boiler manufacturers approve the Code and thus far have carried on the fight for its general adoption. The insurance interests are unanimous in their approval as are many of the largest steam users in the country, who are ordering their equipment built in accordance with its requirements. A large number of states and municipalities were represented at the recent conference at Washington held under the auspices of the Industrial Commission of Ohio, and it was evident that many of them will soon fall in line. As expressed by an able authority on the subject, it is no longer a question of whether there shall be laws on boiler design and construction, but rather what these laws shall be, and it is generally agreed that the A. S. M. E. Code is the best set of rules available.

Water-Power Developments

As a result of the unsettled condition of water-power legislation and improving economies of steam plants, there has been comparatively little activity in this field. A number of small plants have been built or remodeled and detail improvements have been made in the turbine and the governing mechanism, but there has been no activity in promoting large plants. Since 1912 no grants giving water-power rights have been made by Congress, and the same conditions will no doubt exist until the legislative situation clears. No less than eight bills fair to the public and the corporative interests have been defeated and substitute measures framed by corporation interests met the same fate through the efforts of the conservation element. In the last session of Congress the Ferris bill, a good bill, twice passed the House but met defeat in the Senate. The Shields bill passed the Senate but failed in the House. A substitute measure was offered and at the same time the Senate proposed the Myers bill. Nothing was accomplished.

Electricity

The past year has not brought about any marked advances in the electrical industry; the tendency has been toward an improvement of the apparatus to insure a greater reliability of operation, closer voltage regulation and greater protection to the equipment. The size of the generating units have been steadily increasing to meet the requirements of the increased sizes of turbines. Large orders for rotary converters have been placed, these machines ranging in size from 4,000 to 6,825 kw.

In the electrical distribution of energy probably the most notable achievement during the past year is the placing in successful operation two 5,000 kv.-a. shunt-phase converters and voltage balancers in the plant of the Philadelphia Electric Co. These machines make it possible to take a single-phase load from a polyphase system keeping the latter balanced as to voltage and current. These machines have successfully taken care of 20,000-kv.-a. single-phase load swings. This marks an important advance forward in supplying all the needs of a community for light and power from the same source.

It is also worthy of note that wireless telegraphy has found a place of usefulness in the electrical transmission of energy. Two of the large western power companies have installed wireless stations as a means of communication along their transmission lines when other sources fail.

The past year has seen part of the electrified zone of the Chicago, Milwaukee & St. Paul Ry. put in operation. This is one of the most extensive electrifications ever attempted consisting of 440 miles of mountainous track.

Direct current at 3,000 volts is used. By regenerative braking on the down grades from 12 to 15 per cent. of the energy taken from the high-tension system is returned.

On account of the scarcity of copper, iron has been substituted in many cases in Europe for house wiring, transmission cables and to some extent in the construction of electrical machinery. How this will effect the electrical industry of the future is not possible to predict at the present time.

"Safety First" has been given important consideration in the construction of electrical equipment; 1916 has seen many new devices developed for the control of electrical apparatus and circuits that embody safety first features. The Bureau of Standards has issued its second tentative "National Electrical Safety Code" and it is to be desired that in the retrospect for 1917 it can be written that this code has been adopted and become national in its scope.

Improvement in Refrigeration Methods

Over a long period of years there has been little advance in refrigeration. The general principles and methods employed have remained much the same. During the last year economies were effected in the compression system by the use of more economical prime movers in the form of uniflow and high-grade poppet-valve engines. Another step toward higher economy in the production of low temperatures is the new D. I. Davis two-stage system of compression, reducing the range of operating pressures in each cylinder and increasing the volumetric efficiency. It is a great improvement over the booster method used in the past. A reduction of thirty to fifty per cent. in steam per ton of refrigeration over that used normally in low-temperature work is estimated.

Fuel and Smoke Prevention

In the coal field the outstanding feature is the great advance in price, caused by the excessive demand, a shortage of cars for shipment and labor conditions. The present top prices for fuel are of course only temporary, but a return to the close margins of former years between profit and loss cannot be expected. In the first six months of 1916 the output of bituminous coal was the greatest ever recorded in any half-year period. Estimates indicate that the production during this time reached 261,000,000 tons, an increase of thirty-five per cent. over the first six months of 1915 and five per cent. over the last half of the year.

In the first six months of 1916 great quantities of petroleum were marketed, the production being estimated at 140,000,000 barrels. Although this output is less than for the same period in 1915, it is greater than one-half of the total quantity marketed during the year, and all indications point toward the establishment of a new record for 1916. As in other fields, high prices have been prevalent.

Results from locomotives equipped for powdered coal continue to show decided advantages for this fuel. The defects of this system of burning met in practical operation are being eliminated, and the progress has been such that wide use of this fuel by railways is predicted. In the metallurgical field it has been shown recently that the use of this fuel in billet furnaces greatly reduces the scale, thus saving large quantities of metal. Its use in the power plant is still in the experimental stage.

The use of coke-oven gas as boiler fuel has been tried with excellent results by the Toledo Railway and Light Co. To increase flexibility of operation and to obtain maximum capacity, arrangements were made to burn 9,000,000 cubic feet of this gas per day in combination with coal fed into the furnaces on chain grates. It is a suggestion that might be profitably followed where this fuel is available.

During the year active campaigns for smoke prevention have been conducted by Louisville and Lexington, Ky., the latter city eventually passing an ordinance to take effect Jan. 1, 1917. The Detroit Board of Commerce has started a vigorous campaign to abate the smoke nuisance in that city, and for the past year Columbus has been particularly active in this direction. In the last review Chicago was reported to be resting on its laurels. It is to be regretted that as much cannot be said at this time. The smoke situation has gradually grown worse, and it only goes to show that politics and efficiency do not mix. It has remained to Pittsburgh to inaugurate a smoke-abatement week to discuss what has been done, what is possible and future needs to eliminate smoke.

Isolated and Municipal Plants

Owing to higher economies in central stations, reduction in rates and the increasing cost of coal affecting most the smaller user, the margin favoring the isolated plant over purchased service is becoming less. This will necessitate closer attention to operating economies than has been common in the past, and a system of accurate records taking all factors influencing cost into account. Figures must be available to check the liberal assumptions usually made by central-station solicitors, as a slight increase in the cost per unit may be sufficient to turn the tables. Centralization in power generation and interconnection of distribution and transmission systems is being advocated more widely than ever before. To successfully combat the powerful combinations that would result will require organized efforts by adherents of the private plant and, as a basis of their success, accurate operating data from the individual.

Municipal plants continue to "make good" where politics are a minus quantity and operation is conducted on a business basis. From last year's files numerous cases might be cited where stations, publicly owned and operated, are proving a decided success.

Marine Engineering and Naval Architecture

After years of stagnation, shipbuilding in the United States has at last received a boom, some yards having announced orders that will keep them busy for the next five years. This condition, of course, has been brought about by the European War, the direct factors being congestion of foreign yards with war orders, greatly increased exports from this country, and scarcity of tonnage because of private ships having been commandeered for Government service, and losses due to submarine warfare. At present there are on the ways in American yards vessels totalling over 1,500,000 tons, nearly one-third of which will fly the Norwegian flag. These ships will be mostly for freight and tank service, and while the majority will have steam propulsion, still a large number will be driven by oil engines. For the larger vessels these will be of

the Diesel type, but for small and medium powers the hot-bulb engine is well represented.

All of the later vessels for the United States Navy are being fitted for burning oil fuel exclusively, and in three of the battleships about to be laid down electric drive will be employed. Comparative performances of some of the battleships recently put in commission with those of two or three years ago, show that for all around service there is little to choose between the reciprocating engine, the geared Parsons turbine and the improved Curtis turbine. The results did show, however, that those ships employing a moderate degree of superheat, whether with engines or turbines, were much more economical than those without superheat.

Engineering Societies

Coöperation between engineering societies is gaining headway. A decided impetus was given to the movement by the conference held in Chicago last April at which forty-two different societies, local, state and national, were represented. It is being realized that the engineer must take more interest in the public welfare. His advice and services are badly needed in shaping legislation and in the conduct of public work. To this end individual effort is unavailing. The combined energy of all engineering societies is essential. Coöperation between the local branches of the various national engineering organizations has already borne fruit, and if the appointment of the Naval Advisory Board may be an indication, the National Government is beginning to realize the importance of the engineer. It is evident that a new era is at hand and that the engineer must assume his proper sphere in curbing political ignorance and selfishness and guiding the Ship of State to the benefit of the public.

The Honor Roll for 1916

Of the men honored for engineering achievement, mention should be made of Dr. Elihu Thomson, who was awarded the John Fritz Medal. His electrical inventions and his work in electrical engineering, industrial development and scientific research are too well known to need further elucidation. Dr. L. H. Backeland, inventor of synthetic insulating materials, was awarded the Perkins Medal for eminence in industrial chemical research. The City of Philadelphia, acting on the recommendation of the Franklin Institute, awarded the John Scott Legacy Medal and Premium to Clement F. Street, of New York City, for the Street locomotive stoker. Dr. Robert Gans, of Pankow, near Berlin, Germany, received the Elliott Cresson Gold Medal from the Franklin Institute, for "Permutit." Ambrose Swasey was elected to honorary membership of the American Society of Mechanical Engineers.

A notable event was the unveiling at Liverpool, Eng. of a monument in honor of marine engineers. It is an appropriate memorial to those obscure heroes who have died in service and well deserve a place in the heart of public appreciation. In the closing days of the year came word of a fitting tribute to a great engineer. The Engineers Society of Western Pennsylvania gave the initial impetus to a movement to buy the Pittsburgh home of George Westinghouse and turn it into a public park, to be known as the Westinghouse Memorial Park and to be maintained by the city.

Of the various engineering societies closely related to the power-plant field, the following men were elected to the presidencies: Dr. Ira N. Hollis, American Society of Mechanical Engineers; H. W. Buck, American Institute of Electrical Engineers; H. A. Wagner, National Electric Light Association; John A. Kerley, National Association of Stationary Engineers; Harry M. Hart, American Society of Heating and Ventilating Engineers; Byron T. Gifford, National District Heating Association; N. H. Hiller, American Society of Refrigerating Engineers.

Necrology

A number of men prominent in the field passed away during the year. The files of *Power* record the following: John A. Hill, organizer and president of the Hill Publishing Co.; James D. Farasey, prominent in the boiler-making industry and owner of the H. E. Teachout Boiler Works, of Cleveland; Harry S. Pell, a prominent steam engineer for many years with the Stirling Boiler Co. and the Erie City Iron Works; Col. John C. Hooven, president of the Hooven, Owens, Rentschler Co.; Frank Hastings Varney, one of the best-known electrical engineers of the West, connected with the Pacific Gas and Electric Co.; Dr. Charles J. H. Woodbury, a noted authority on fire hazards, economics, engineering and textile affairs; Daniel Halladay, builder of the heat engine invented by John Ericsson, designer of the famous ironclad "Monitor"; Erasmus Darwin Leavitt, famous designer of pumping and hoisting machinery and one of the thirty engineers who organized the American Society of Mechanical Engineers; Eric Gerard, Belgian scientist and director of the Montefiore Institute; John E. Sweet, one of the most widely known and highly esteemed men of the older generation in the steam-engineering field; Robert Allison, inventor of the Allison cataract steam pump and owner of the Franklyn Iron Works; George W. K. Taylor, a member of the McMann & Taylor Co., designers and makers of piping, valves, fittings and other goods pertaining to steam, water and gas; Enos M. Barton, founder of the Western Electric Co.; Dr. Elmer L. Corthell, president of the American Society of Civil Engineers and one of the most noted men of his profession; William Stanley, a prominent electrical engineer and inventor; Chauncy J. Blair, millionaire financier and at the time of his death president of the Kennicott Co.; Silvanus P. Thompson, noted English electrical engineer and physicist; John J. Jenkins, Omaha's first boiler inspector and builder of one of the first stationary engines used in Nebraska; George Gilmour, chief engineer of the Travelers Insurance Co.; Wiliam A. Warman, a designer of special machinery for the Keller Mechanical Engraving Co., of Brooklyn; Charles Kirchhoff, a noted mining enginer, at one time editor of *Iron Age* and vice-president of the David Williams Co.; Sir William Ramsay, the eminent English chemist; Emil Herter, chief mechanical engineer of the Edison Storage Battery Co.; John Muir, supervisor of power plants for the New York Telephone Co.; Frank E. Shedd, vice-president and chief engineer of Lockwood, Greene & Co., Boston; James Lunsden, treasurer of the steam-piping contracting firm of Lunsden & Van Stone, Boston; John E. McIntosh, one of the founders of McIntosh, Seymour & Co.; Theodore N. Ely, engineer and retired chief of motive power of the Penn. R.R.

The Prevention of Vibration in an Apartment House

SYNOPSIS—Vibration in a new apartment house was so much in evidence that the tenants began to leave. The trouble was eliminated by making a few changes in the piping and by installing shock and sound arresters, so that there is now no connection between the piping of the power plant and the building proper.

Up to within a short time ago the tenants of the 18-story fireproof apartment building, Fig. 1, at 1830 South Rittenhouse Square, Philadelphia, Penn., were annoyed by vibration from the engine-room units. This was so pronounced that the pictures on the wall and the chandeliers over the dining-room tables would rattle and there was danger of the tenants moving out; in fact, some of them did. With thirty-one apartments renting at from $2,500 to $10,000 per year, the situation was serious and steps were taken to remedy the trouble. The building was only a little over two years old. The solution of the problem was placed in the hands of C. F. Wendland, consulting engineer, of New York City, who, after investigating the conditions in the building, decided that all annoyance from vibration could be eliminated by making some changes in the piping system and by using his patented system of shock and sound arresters. In the boiler room there are two 150-hp. and one 250-hp. return-tubular boilers, connected through 7-in curved pipes with a 10-in. main steam header that extends across the front of the boilers, as shown in Fig. 2. Originally, the connections between the boilers and the header were made with tee fittings; but as an aid in preventing vibration and to obtain a more mechanical job, the connections were changed to as long-radius bends as conditions permitted. Similar conditions existed in the engine room, and bent pipe connections are now taken from the main steam pipe to each of the engines, of which there are three—one 12x24-, one 18x36- and one 22x38-in. high-speed engines directly connected to 75-, 125- and 175-kw. direct-current generators respectively. The three-wire system is used, the lighting circuits being 110 volts and motor circuits 220.

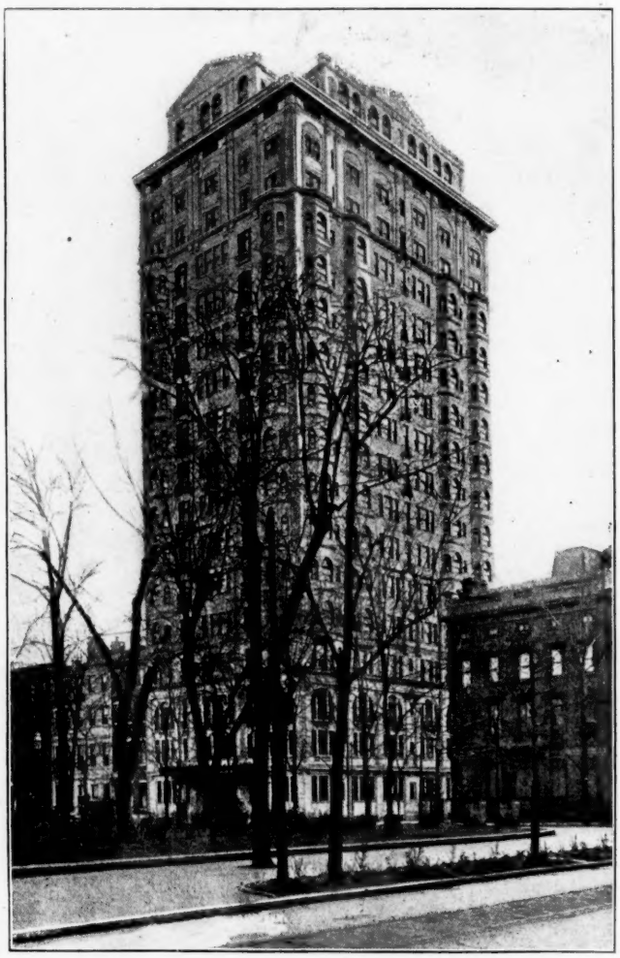

FIG. 1. EXTERIOR OF THE APARTMENT HOUSE

From the 10-in. steam header in the boiler room an 8-in. pipe runs at right angles through the wall to the engine room, where it turns at a right angle and extends lengthwise of the room, Fig.3. Under former conditions this was the only source of steam supply to the engines, and in case of an accident to the header or main steam pipe, every unit in the building would have to be shut down until repairs could be made.

This deficiency was remedied by running a 4-in. auxiliary header above the boilers and connected to each by a 4-in. leader. The header was extended to a point above the 8-in. main steam line and supported by suitable metal supports that rest upon the main steam line. In the engine room a 4-in. bent branch line drops to a 75-kw. unit from the auxiliary line, Fig. 5. At the end the auxiliary line bends down and connects with the end of the 8-in. steam main. This is shown in Fig. 2. The 8-in. main is valved so that in case of an accident to the main header or a portion of the main steam line, the plant or any engine can be operated from the auxiliary line. The branch lines to the two larger engines are 6-in. and are shown in Fig. 4. In each instance the connection to the engines is made with U-bends, as shown in the illustrations. Although these changes in the piping system were an improvement in the general design, they were not expected to have any material effect on the vibration trouble. This was taken care of by the use of shock arrester and sound absorbers, the detail construction of which is shown in Fig. 6. The purpose of this device is to prevent the passing of vibration or noise from a body and its supports to the building proper. Referring to Fig. 6, *A* represents a pipe resting on a roller *B*, that is supported by a yoke *C*, having a screw thread stem *D* that enters a cap piece *E* and is supported by the nut *F*. The cap *E* is made with a centering projection *G* within which is a resilient composition insulation *H*, that has a projection *I*, and over which one end of the spring *J* fits. The bottom end of the spring rests on a resilient insulation which fits into a base cap similar to the top one, and which is made flat on the bottom. By means of nut *F*, each of the shock arresters may be adjusted to support its proper proportion

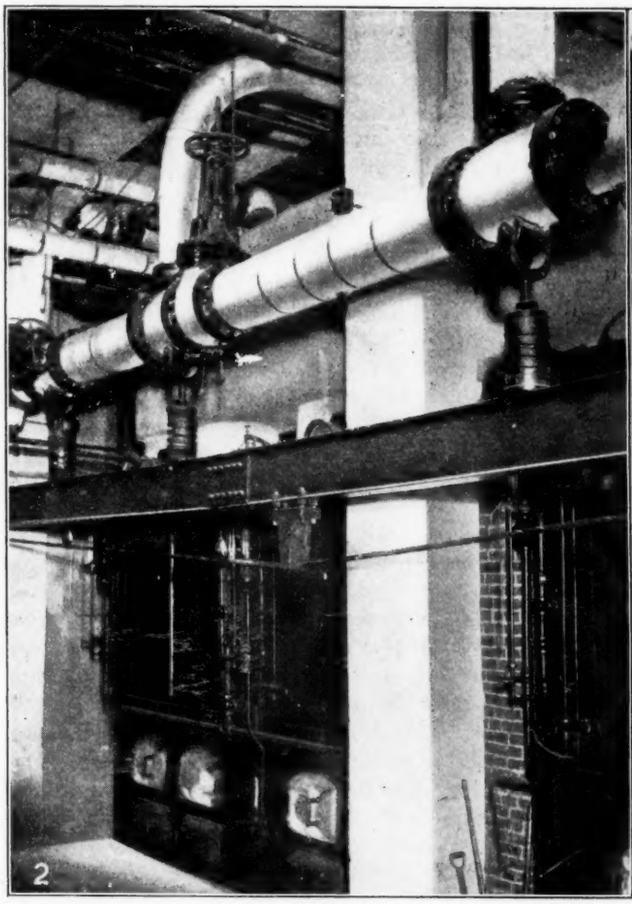

FIG. 2. HEADER IN FRONT OF BOILERS AND SHOCK ABSORBERS

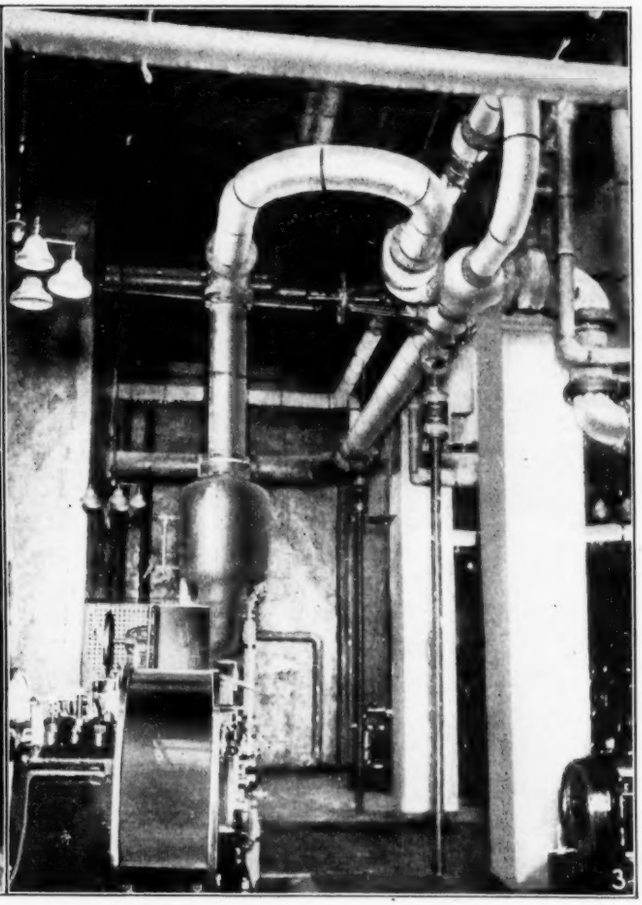

FIG. 3. ENGINE-ROOM HEADERS AND SHOCK ABSORBER ON PIPE SUPPORT

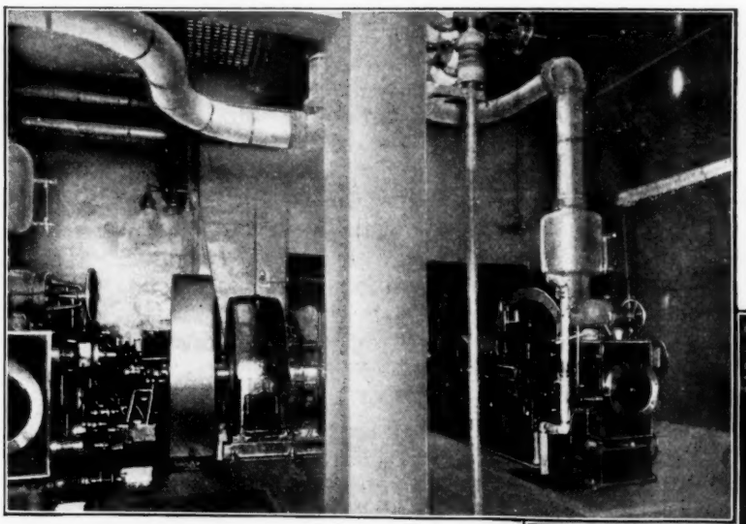

FIG. 4. ENGINE PIPING AND SHOCK ABSORBER

of the total weight of the pipe line to be carried. It will be seen that the roller permits the pipe to move longitudinally and that the combination of the resilient composition members and the spring prevents the transmission of vibration to which the steam pipe may be subjected to the building. In Fig. 2 is shown the application of three shock arresters to the main steam header. They are supported on an I-beam that is secured in the boiler-room walls, but insulated from them. It is braced by a 1-in. wire cable that runs over a central saddle, as shown. In the engine room the main steam line is supported by 3 arresters, each mounted on a 2½-in. pipe support that rests on the flooring. The supporting pipe stands are braced by brackets that are bolted to the iron beams of the columns shown in Fig. 3. Although the method of preventing the transmission of vibration to the building is simple,

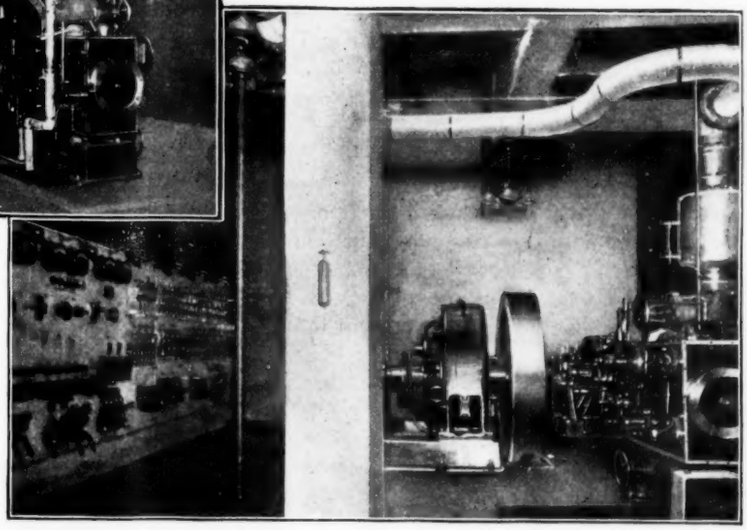

FIG. 5. SWITCHBOARD AND SMALL ENGINE UNIT

it has been effective, and a visit to various parts of the building fails to detect any signs of the previous annoyance. Tenants are furnished without extra charge light, heat, hot water and sterilized drinking water, refrigeration and ice for table use and vacuum-cleaning service. Gas or electric ranges, electric warming ovens and incinerators for the burning of garbage are installed in each kitchen. Refrigeration is supplied by a 20-ton motor-driven machine. It produces three tons of ice per day, the rest of the capacity of the machine being used for refrigeration. Vacuum cleaning is had by a 16x32-in. vacuum machine driven by a 4-hp. direct-current motor. All electric circuits are controlled from an eight-panel marble switchboard, Fig. 5. Three panels are for the generators, one each for motors, elevators and regulators and two for lighting service. There are four electrically-operated elevators, two passenger and two service, the latter being used by the servants and to bring provisions, furniture, etc. to and from each apartment by means of a rear entrance, that is in no way connected with the main hall. The main entrance hall possesses a luxurious but quiet dignity and the high ceiling and broad archways give an unusual impression of architectural refinement to the large apartments, which are fitted alike for comfort and extensive entertainment, and are characterized by a sense of light and heat. The building and steam plant are in care of O. Anderson, superintendent and chief engineer.

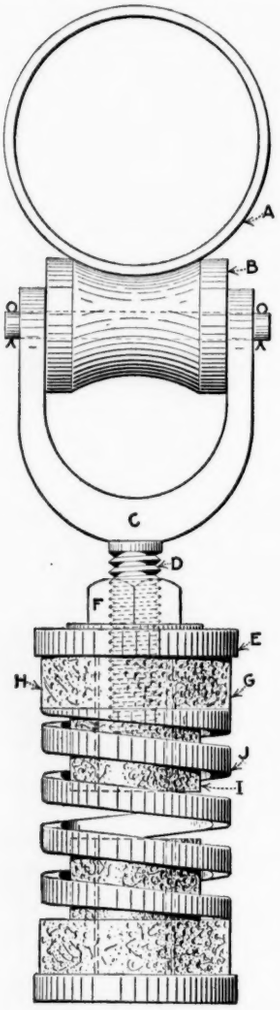

FIG. 6. DETAILS OF SHOCK ARRESTER

Oil Coolers for Steam Turbines

By A. G. Christie*

It is quite general practice to use some form of oil cooler on steam turbines, particularly on those of larger sizes. These are of several types, in some of which the water is circulated through tubes in a suitable chamber through which the oil passes on its way from the bearings to the oil pump. In other types the oil on its way from the pump to the bearings is forced through the tubes placed in a chamber containing water and is thereby cooled. In still other types small copper tubes are embedded in the babbitt of the bearings, and water circulated through these tends to keep both the bearings and the oil cool. The selection of the type of cooler has so far been largely governed by the individual taste of the turbine builder.

From an operating point of view there are a number of important considerations that should be kept clearly in mind when deciding on a cooler design. In the first place, the available water for cooling purposes in many plants is not absolutely clear at all times of the year. The sediment tends to deposit in the oil coolers either from heating or from low velocity of flow. The accumulation of dirt quickly decreases the effectiveness of the cooling surfaces, and the cooler must therefore be cleaned. Hence it should be so built as to be readily accessible and easy to clean. If the water passes through spiral tubes or through tubes of a doormat form, or even through return bends, it is not always possible to run a scraper or cleaner through the tubes. These classes of heater are therefore at a serious disadvantage where the water is likely to contain sediments, as compared with those having a nest of straight tubes that can be readily removed and cleaned with a scraper. Steam or chemical solutions must be used to clean the bent tube coolers. Such methods are troublesome and inconvenient. When facility for cleaning is considered, operating conditions seem to favor the straight-tube cooler when the water passes through the tubes. With oil inside the tubes the water chamber has merely to be accessible by a hose nozzle to wash the sediment from the tubes.

The question of heat transfer is an important one when considering oil-cooler types. Mineral oils do not readily transmit heat. Hence one finds that the heat transfer is in the neighborhood of 15 to 20 B.t.u. per square foot per degree difference in temperature per hour. This is remarkably low when one considers that a transfer rate of 350 to 400 B.t.u. per square foot per hour per degree difference in temperature is usual in a steam condenser.

On the other hand, the temperature differences in an oil cooler are usually high, for it is now customary to supply oil to steam-turbine bearings at 130 to 150 deg. F. The cooling water, however, is seldom heated to within 30 or 40 deg. of this temperature. The coolers therefore require considerable water, and this is quite warm when it leaves the cooler. If this water can be passed into a heater and used for boiler feed, this waste heat could be utilized to advantage. When, however, the water simply runs to a sewer, the amount used for cooling may become a considerable item of cost.

One is led to ask which cooler is more effective, the one with water in the tubes or the one with oil passing through the tubes. With small tubes and high velocities, it is probable from theoretical considerations that the cooler with oil passing through the tubes would be more effective. But this requires the pump to lift against a higher pressure, and with rotary pumps there is then a greater slip in the pump with the hot oil, hence greater power is wasted in driving the oil pump. Turbine builders seem to have compromised on moderately effective oil coolers and small power requirements for circulating oil. In practice there seems to be little to choose between the two types of cooler.

In turbine operation the oil coolers should be kept clean and the consumption of water thereby reduced to a minimum. Many engineers run their oil much cooler than necessary in their turbines; 130 deg. F. is not at all dangerous and saves water in the coolers.

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The Installation of Motors—I

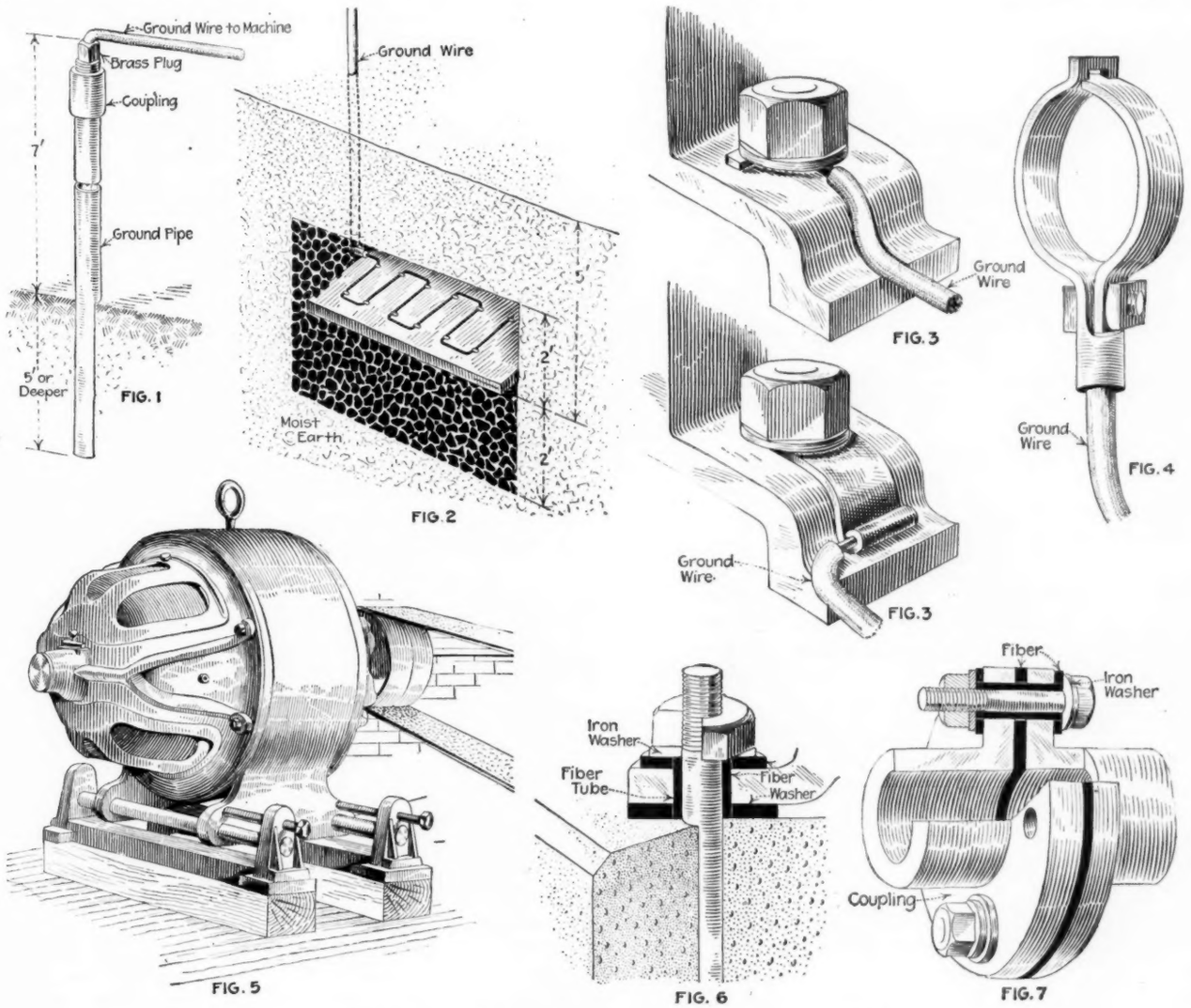
By R. Thistlewhite

SYNOPSIS—This is the first of a series of articles on the installation of electric motors and treats of the methods of grounding and insulating the motor frame. It is the intention in these articles to give special attention to that part of the Board of Fire Underwriters' Rules that applies to the installation of electric motors and the reasons for such rules.

Before 1897 there was no prescribed standard to which the installation of electrical work had to conform. The consequence was that the cheapest kind of material was used and due regard was not paid to the safeguarding of life and property. At about this time, through the united efforts of the various insurance companies and engineering societies, a code of rules was drawn up to cover all installations of an electrical nature, and this was adopted both by the insurance companies and by the municipalities throughout the United States. In addition to these rules there are local ordinances which are enforced by city authorities and central stations in the districts where they have control.

In general, electric work of all kinds—machines, conductors, etc.—however well insulated, should be considered as being alive and treated in such a way that under no condition can a short-circuit or a ground occur, and insulated so that leakage between conductors and between conductors and ground will be reduced to a minimum. The mechanical construction of the work should receive special attention, especially the careful and neat running of wires, the making and soldering of connections and the securing and attaching of the wires to the terminals of the fittings. All these things are conducive to the safeguarding of life and property.

Avoid complicated wiring and make all reasonable efforts to place distributing centers in accessible positions and have all switches grouped in one place if possible. It is also recommended that all wires be concealed and at the same time accessible.



FIGS. 1 TO 7. METHODS OF GROUNDING AND INSULATING MOTOR FRAMES

The National Board of Fire Underwriters' Code specifies that all motors operating on circuits of 550 volts or less must have their base frame positively grounded; but where this is impracticable, special permission may be given to omit this, although in such a case the machine must be insulated from the ground. All machines operating at a potential above 550 volts must have their base frames permanently and effectively grounded. A ground is understood to be a permanent electrical connection to the earth, which is made in a number of different ways. Water pipe, gas pipe on the street side of the meters, sprinkler pipes, depending on the size, are all considered to be properly connected to the earth, and ground wires can be attached to them.

A length of galvanized pipe may be driven into the ground until it is in contact with permanent damp earth and extending at least 7 ft. above the surface of the ground and 5 ft. below if moist earth can be reached at this depth. If there is any difficulty about making good contact between the pipe and the earth, owing to lack of moisture, dig a pocket around the pipe to a depth of 4 or 5 ft. and pack pea-size coke or charcoal very tightly around it. The grounding wire is fastened to the pipe by soldering it to a brass plug screwed into a coupling that is placed on the end of a pipe after it has been driven into the earth. This is the most common method of forming a ground where there is no other ground available, and is shown in Fig. 1.

Installing a Ground Plate

Where several devices are to be grounded, especially if they are close together and the ground connection has to be made for each, a copper plate of about No. 16 Stubbs gage (approximately 0.065 in.) can be buried in the earth to a depth of about 5 ft. and packed on both sides with 2 ft. of crushed charcoal or coke. A copper wire is riveted to this plate in several places and hard-soldered along its entire length, as indicated in Fig. 2.

Permanent connections of this nature are required so as to insure the passing of any leakage that may occur directly to the ground instead of through the wall, pillars and beams of the building, and then into the earth. The ground wire, which is run from the machine to the ground, must be installed in the same manner as any other wire.

Connections to the machine can be made under the foundation bolts, either by means of a wire directly clamped between a washer and the frame of the machine or by means of a copper strap which will go under the foundation nut and lie to the same shape as the bed and terminating in a cup or curl, as in Fig. 3, into which the ground wire must be soldered. The connection to the ground pipe is made by means of the brass plug, as already mentioned, or by means of a regulation ground clamp (Fig. 4). On no account is the wire to be twisted around the ground pipe and soldered, as this by no means forms a good electrical connection.

Where permission has been obtained to omit the ground, the machine must be insulated. Wooden base frames for this purpose can be obtained which also form a belt-tightening device, or the motor may be mounted on wooden beams, as in Fig. 5. In either case the floor under the motor must be filled; that is, painted with a good moisture repellant, such as boiled linseed oil, and the space under the motor arranged so that dirt cannot accumulate, and so as to allow an easy means of cleaning.

When the machine is mounted on a concrete or stone foundation, it is insulated by placing pieces of fiber under the feet of the motor and fiber tubes and washers on the foundation bolts, as in Fig 6. Where the machine is direct-connected to the load, insulation is placed between the faces of the coupling and on the coupling bolts, as indicated in Fig. 7. Owing to the constant strain and vibration that the coupling insulation is subject to, it is not very reliable; it should be constantly watched for leakage and kept free from oil and grease. It is for this reason that the large machines, which necessarily require large couplings, are not insulated.

Unless the motor is totally inclosed, it will be necessary to place it under a wooden box lined with ⅛-in. metal or asbestos, as shown in Fig. 8, arranged so that it can be readily removed for inspection, cleaning and oiling. Ventilators are cut in the sides and covered with fine wire mesh or screens. A motor so covered can be used in places where there are inflammable materials flying around, but would not be allowed where inflammable gases are given off from the work being done. In the latter case a totally inclosed motor would be the only kind that could be used on account of the fire hazards that are always present.

Resistance boxes, starters, etc., must be installed at least one foot from all combustible materials, unless they are mounted on a slate base. The arrangement shown in Fig. 9 is a very good one for mounting a starter; Fig. 10 shows how the apparatus is fastened to the base. No matter what kind of apparatus is to be mounted, the same construction will have to be followed; separate screws will have to be used for supporting the base on the wall and for fastening the apparatus to the base as shown. The hole in the back of the base must be countersunk and filled with an insulating wax. The starting box must be so arranged that it is impossible to leave the arms in any position except the first and last contacts. The no-voltage release should operate whenever the voltage is decreased to such a value and for such a length of time that it will allow the speed of the motor to be reduced to one-third its normal value.

Installations in Damp Location

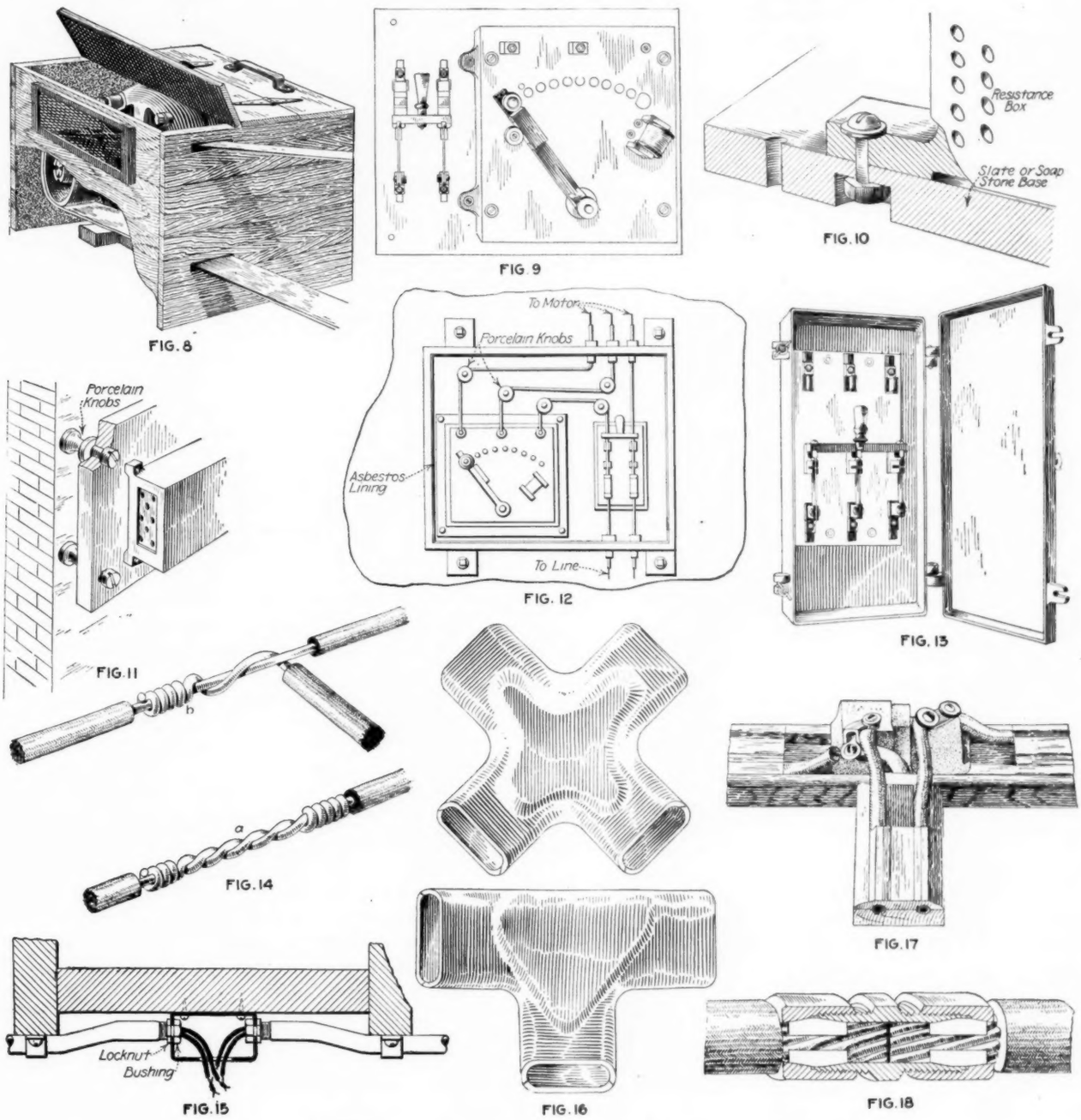
In damp locations it is preferable to inclose the switch and starter in a damp-proof box or mount them upon porcelain knobs so that there is a space of one inch between the wall and the slate base, as in Fig. 11. In dusty and dirty locations the starter and switch must be placed in a dustproof box fitted with self-closing doors. A wooden box lined with metal or asbestos is used when the wires entering it are run in wooden molding or on knobs (Fig. 12), and an iron box when the wires run in metal. The wires enter the wooden box through porcelain tubes, as shown, the hole in the tube being completely filled with the wire; if this is not the case the insulation of the wire must be built up with friction tape until it does fill the hole.

Where switches have to be placed in boxes, the latter must be large and deep enough to allow the switch to be placed in any position and the door closed for all switches up to 30 amp. capacity. For larger switches than these it is only necessary that the switch can be opened to its full extent. Fig. 13 shows a metal box with the cover

open that permits the switch to be operated without making the box too deep.

In general the wires used must not be smaller than No. 14 B. & S., no matter how small a current the motor requires. They must be properly spliced and soldered and the splices covered with an insulation of rubber over which a layer of friction tape is placed to hold the rubber. The kind of splice and its treatment will depend upon where and how it is installed. The insulation should be taken off the wire in a manner similar to sharpening a lead pencil. This is advantageous for two reasons: First, there is no danger of nicking the copper, therefore preparing the way for a broken wire; second, it allows a better connection between the insulation on the splice and the outside covering of the wire. Where there is any strain on the joint, a Western Union splice should be used, as in Fig. 14 a. This would apply when the wires are run on knobs, perfectly open and in plain sight.

All splices must be made so that they can be inspected at any time with the least amount of trouble. In conduit work the tap shown in Fig. 15 can be used, but must be placed in an iron box and covered by means of a blank cover. This also applies to armored cable work. In metal molding the tee and crossover fittings, Fig. 16, will allow ample room to make joints and can be used for such. In wooden moldings a special fitting shown in Fig. 17 has to be used, the joint here not requiring any solder. Solderless connectors which can be used in any class of wiring, especially on standard cables, are shown in Fig. 18; the outside will be insulated in the same manner as any other joint.



FIGS. 8 TO 18. CONSTRUCTIONS AND DEVICES USED IN MOTOR INSTALLATIONS

Connections to apparatus of any kind can be made under a screw head and washer provided that the wire to be connected is not larger than a No. 8 B. & S. When the wire is larger than this, it must be soldered into a copper terminal lug, which in turn must be screwed to the apparatus. The correct method of connecting to a terminal lug is to bare the wire so that there is just enough copper exposed to reach to the bottom of the lug. Then fill the lug with solder and insert the wire; hold it in the lug perfectly steady and dip in cold water or hold it against a piece of wet waste. This will set the solder rapidly, and if the wire has not been moved, a perfectly good electrical connection will be made. A layer of tape over the insulation and a portion of the lug will complete the joint.

Boiler-Room Safety Pointers

By M. A. Saller

It has been estimated that over 2,500,000 accidents occur yearly in connection with the industrial plants of this country and that 60 to 70 per cent. of these mishaps can be traced directly to carelessness and lack of proper safeguards.

This matter is of extreme importance in power plants, because accidents which develop there may prove disastrous, not only involving the parties responsible, but causing money loss, inconvenience and even danger to others. The safety slogan should therefore be impressed on all who are connected with power-house work and no effort spared in bringing to their attention, by means of bulletins, notices, framed instruction sheets, etc., the importance of the careful observance of all precautionary measures; and wherever possible the human element should be eliminated or minimized by arranging the equipment in such a manner and with such safety appliances that it is made difficult for the operators to make mistakes and expose themselves to danger.

Good substantial hand-rails should be fitted on all stairways and narrow gangways, especially the dark, steep ones, for it is quite a common occurrence for men to sustain serious falls because of a misstep or slipping on stairways. A railing of the proper height will in many cases enable the man to check himself without danger. Metal stair treads become dangerously slippery after the rough surfaces are worn down. A securely anchored and railed walk should be fixed along coal trestles and pockets, around water tanks, etc., where the operators are called upon to go, and along the tops of the boilers parallel to the steam headers and near the stop and safety valves, and permanent ladders of generous proportions should be provided. A loose ladder hastily placed and ascended is productive of hundreds of accidents.

Special attention should be paid to lighting up all the dark passageways and stairs, as there is always the possibility of something being placed therein over which a person may stumble or fall. Where it is necessary to visit such dark places only once in a great while, hence wasteful to have them continuously illuminated, lights should be installed so that they can be turned on by means of a snap switch when necessary. It is highly important to have plenty of good, clear light around pressure and water gages, etc., to avoid mistakes in taking off readings.

Put rubber pads on iron stairs or floor plates or rough up with a chisel or roughening tool when worn down smooth. See that all floor planking is kept in good condition and securely fastened down so that a solid, smooth carrying surface is presented. Special lookout should be kept for rotted planks or supports which may give way. Also covers to sumps, hotwell pits and manholes should be kept in good condition and securely in place, for they readily work loose, warp and become wabbly when stepped on. It will pay to have floor boards treated with a creosote filler or else covered with a heavy coat of tar.

Impress upon all the operators the desirability of opening water and steam valves carefully and slowly to prevent excessive shocks on the pipe lines and water-hammer.

Provide cages or covers made of light-weight wire screen or a simple guard railing for all moving parts of machinery which offer possibility for injury, such as stoker gears, stoker engines, moving belts and flywheels. Arrange the outlets for hot water or steam in such a manner that the possibility of scalding passersby is eliminated. These discharge outlets should be connected to the sump or exhaust pits. Do not discharge even low-pressure traps horizontally from the building in areaways or passages, because their sudden discharge, releasing hot water and steam, is apt to scald anyone working in that vicinity. It is also poor practice to discharge the boiler blowoff horizontally out into the open, even where the plant is isolated, because there is always the possibility of someone being near the outlet and being scalded by the sudden blast.

Safety Valves Should Be Tested Daily

Impress upon all the necessity of being positive that safety valves are of ample size and in proper working order at all times and that they cannot be tampered with and overloaded. Try each safety valve at least once every day to make sure that it is operative at the desired pressure limit. Pressure gages should be tested and calibrated at regular intervals to insure that they indicate accurately.

It is best not to rely entirely on the gage-glass or high- and low-level alarms actuated by floats, etc., but instead, trycocks should be placed in the boiler at various levels and blown at frequent intervals in order to check the indication of the gage-glass. Fusible plug should also be inserted at the minimum low-water line.

Gage-glasses should have protecting guards that do not blur or make indistinct the reading. When putting new glasses in high-pressure gage fittings, it is advisable to admit the pressure slowly so that the glass may gradually heat up and adjust itself to the pressure conditions. It is an excellent precautionary measure to place a board in front of a new gage-glass so as to protect the operator from flying gas and steam in case the glass should prove defective and burst.

When a boiler is shut down for cleaning, it should be carefully examined for cracks, pitting, bags, etc., and to see that all the stays are tight. The boilers should also be regularly examined and tested by a reliable boiler-inspection company. Never neglect a leak or defect in a boiler however slight it may appear—have it repaired promptly.

While boilers are out of service for cleaning or repairs, the valve between the steam header and the boiler should be locked and tagged so that there will be no possibility of the steam being turned into it until steam has been raised in it and the boiler is ready to be put back into service. Guard against the accumulation of large quanti-

ties of scale in the boiler; for one thing it is liable to cause overheating and bagging of the boiler plates or burning of the tubes, often resulting in a dangerous explosion.

It is excellent practice to provide the fireman with amber-colored glass goggles to relieve the glare of the bright fires and protect the eyes in case of a bursting tube which sends through the fire-door a shower of hot coals and ashes.

Proper racks for holding the stoking tools should also be provided so that they are not scattered about the boiler-room floor, a source of danger and inconvenience to everybody concerned.

Steam-Engine Troubles—Pistons

By H. Hamkens

SYNOPSIS—This is the first of a series of articles on Corliss-engine troubles induced primarily by features of design. Good design is contrasted with bad to guide the purchaser and engineer in the selection of engines. Some troubles due to the fitting of piston rods and to forms of follower bolts are discussed in this article. After treating of numerous engine details the series concludes with some abundantly illustrated articles on foundations and the erection of engines.

For the operating engineer or the prospective purchaser it may be of interest to know which design and construction of different parts of a Corliss engine may best be selected and which should be avoided. In other words, it would be a good thing if engine troubles in general and particular could be listed, so as to give interested parties a chance to forestall costly and dangerous accidents.

Good and Bad Piston-Rod Construction

It seems that engine accidents run in series. Aside from flywheel accidents, which probably cost more lives and money than all other engine troubles combined, many accidents are due to faulty piston-rod construction. Years ago any old connection between crosshead and piston rod was considered good enough, and the cheapest and most dangerous was the most common. A troublesome connection between the piston rod and crosshead is shown in Fig. 1. The rod was slightly reduced in diameter at the crosshead, with a straight fit in the latter. A hole for the key was cut into the rod, with the corners made square. The trouble came as soon as the slight shoulder had hammered into the crosshead or reduced on the rod, creating a pound. The key had to be taken up, more pounding and keying followed and, finally, rupture through the sharp corners of the hole, as shown. The construction is bad and should be avoided.

Fig. 2 shows a piston rod with a taper fit in the crosshead and the hole for the key half-round at the ends. This is a slight improvement over the first-described straight rod. If the diameter of the rod is not increased, the only advantage is that it will not hammer into the crosshead, the taper being about $\frac{7}{8}$ in. per ft.; but the disadvantage is that the taper reduces the diameter of the rod at the farthest end of the keyhole so much that there is not sufficient metal left to resist the alternating forces of the steam pressure acting on the piston and rod, the metal crystallizes and a break results. If the rod is made sufficiently large in the crosshead, with a corresponding increase in the key, the design may be satisfactory.

It is well to investigate the kind of steel in a piston rod. Cold-rolled is not fit, but openhearth forged steel of 0.30 to 0.35 carbon can be recommended. If for reasons of quick repairs or easy dismantling, as in rolling-mill work, a keyed piston rod is desirable, it should be made extra large in diameter and the reduction at the crosshead should be made in three offsets. The diameter

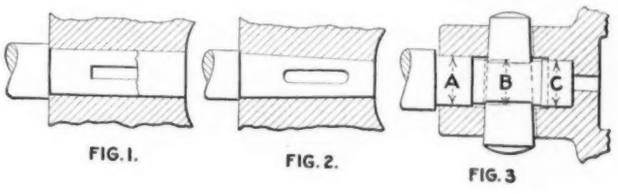


FIG. 1. FIG. 2. FIG. 3

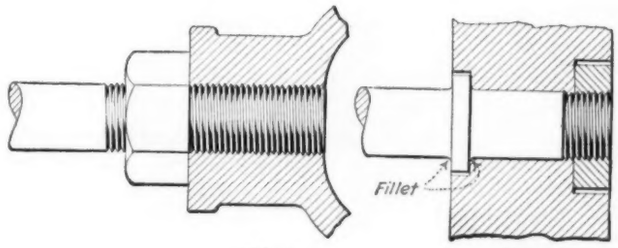


FIG. 4 FIG. 5

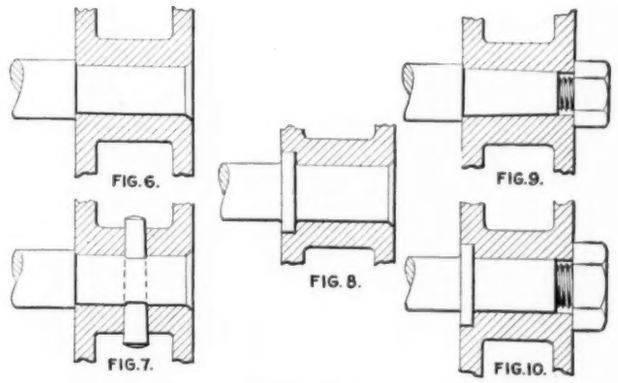
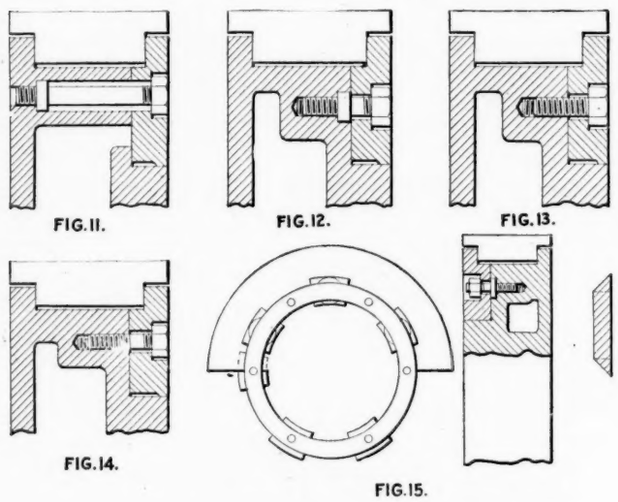


FIG. 6. FIG. 9. FIG. 8. FIG. 7. FIG. 10.

FIGS. 1 TO 10. PISTON-ROD FASTENINGS

A, Fig. 3, should be $\frac{1}{8}$ in. smaller than the rod, *B* $\frac{1}{16}$ in. less than *A*, and *C* about $\frac{1}{16}$ in. less than *B*, and *A* and *C* should be easy driving fits, while *B* should be at least $\frac{1}{32}$ in. loose in the bore. The end of the piston rod should fit against the bottom of the bore *C*, a small hole leading into the center core of the crosshead. The key must be located in part *B*, the key and holes to be half-round at the sides.

A disadvantage of the keyed piston rod is that the clearance in the cylinder cannot be adjusted. Where this is essential, the piston rod should be screwed into the crosshead and provided with a large check nut. The outside diameter of the thread should be about the same as the diameter of the rod and the length of the thread



FIGS. 11 TO 15. PISTON-FOLLOWER FASTENINGS

in the crosshead from 1¾ to 2 times the diameter of the rod. Care must be taken to make the thread a good fit. Fig. 4 shows the connection of a threaded piston rod and crosshead. The number of threads per inch may be made as follows: For 2¼- to 2½-in. diameter rod, 8 threads per inch; for 2¾- to 3-in. diameter rod, 7 threads per inch; for 3¼- to 4-in. diameter rod, 6 threads per inch; for 4¼- to 5-in. diameter rod, 5 threads per inch; for 5¼- to 6-in. diameter rod, 4 threads per inch; for 6¼- to 8-in. diameter rod, 3 threads per inch. The threaded piston rod is to be recommended if economy is desired, for it enables the builder to reduce the clearance in the cylinder to a minimum and to adjust it to be equal at both ends of the stroke.

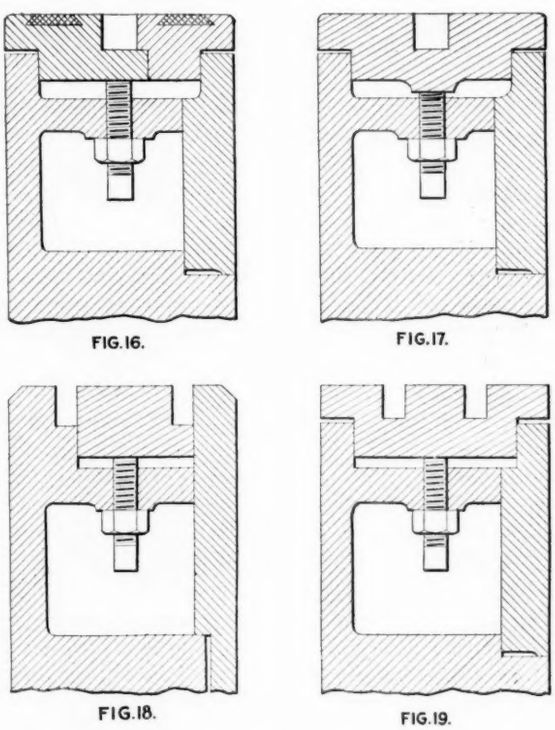
The stress of piston rods in tension and pressure, whether keyed or screwed, should not be more than 6,000 lb. per sq.in. in the weakest section, and the shearing stress of keys and rods must not exceed 5,000 lb. per sq.in. A piston rod occasionally breaks in the piston, but this does not happen as often as in the crosshead. The reason for this is that most of the rods are pressed into the piston-spider, where they are held very tightly and are not subject to hammer action, as at the crosshead end.

Fig. 5 shows a good way of securing the piston rod to the piston. The rod has a large collar against which the piston spider is pressed. Liberal fillets should be turned on both sides of the collar. The end of the rod is threaded and has a steel nut screwed on, which is let into the piston. This makes the face even without any projections. The nut is set up tight and secured by a lockscrew.

Other ways of holding the piston on the rod, frequently used by engine builders, are shown in Figs. 6 to 10. Fig. 6 shows the rod slightly reduced in diameter, pressed into the piston and the end riveted. Fig. 7 shows the same construction with an additional cotter pin driven through; this weakens the rod and is open to the same objections as the key and hole at the crosshead end. If the rod is pressed in solid the cotter is of no use, but if it is not a perfect press fit the hole weakens it so much that there is danger of a fracture. A number of rods have failed at this point and caused much damage. Fig. 8 is an improvement on Fig. 6. The collar on the rod is an excellent thing, but of course there is the uncertainty of the press fit. Figs. 9 and 10 are used frequently. Fig. 9 shows a taper rod with a thread and nut at the end, and Fig. 10 has a straight fit with a collar at one end and thread and nut at the other. Both of these types will hold if the rods are pressed in tight, but the disadvantage is that the large nut projects and causes a continuous loss of steam, for the reason that a cavity for the nut must be provided in the back cylinder head, which increases the clearance space and also the surface on which steam will condense.

Troublesome parts of a piston are the follower bolts, which deserve thorough consideration. For these bolts, or studs, the best grade of Norway iron or its equal should be used; it should be carefully tested for tensile strength and elongation. Mild steel or, worse, high-carbon steel should not be used.

A much-approved follower-bolt construction is shown in Fig. 11. The bolts are made to go through the piston, one end is screwed tight into the piston spider against a collar on the stud, and the end is riveted over to hold the bolt. The shank has play in the hole to give the bolt a chance to bend if not perfectly square with the follower. A nut holds the follower onto the piston. This



FIGS. 16 TO 19. FORMS OF JUNK RINGS

nut is important, for if one comes off there is usually some damage done, either to the piston, the back head or to the exhaust valve and its gear. Some engineers prick-punch the nuts and studs to keep the nuts from backing off; others put in split pins—dangerous things if not properly secured in the holes. If the nuts are not a good fit on the bolts, so that they have to be screwed on all

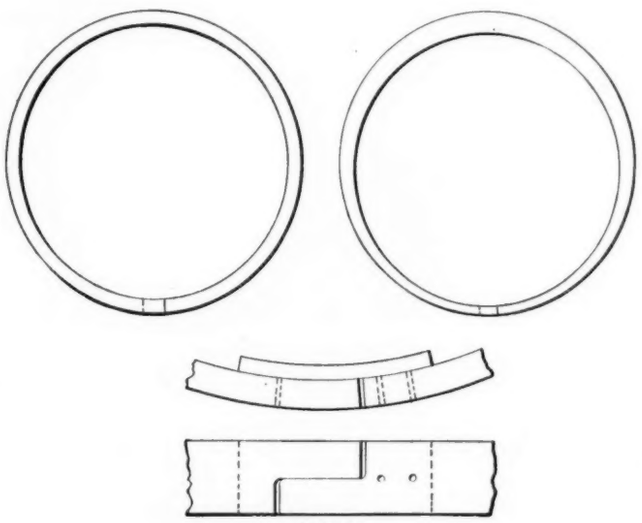
the way with a socket wrench, they cause the engineer a lot of worry. The bolts and nuts should be given the most rigid inspection and replaced if not perfect.

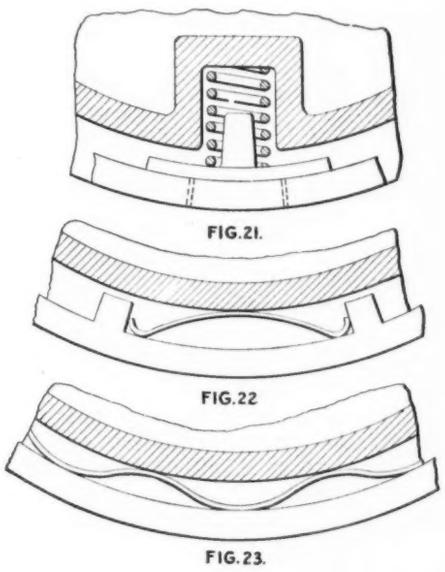
Follower bolts of different designs are shown in Figs. 12 to 14. Figs. 12 and 13 are similar, the only difference being that the studs in Fig. 12 are provided with a collar and therefore cannot back out or become loose as long as the follower is in place. The only thing that can come off in the design shown in Fig. 12 is the nut. Fig. 13 shows a stud screwed tightly into the piston, with a nut to hold the follower. The disadvantage of this is that the stud may come out, since there is nothing except the tight fit in the tapped hole to hold it in place. In Fig. 14 a tapbolt with a long thread is used—not such a bad construction in itself if the bolt is made a close fit in the tapped hole and if the thread is perfect, but often this is not the case and then there is trouble. Besides, every time the follower is taken off bolt and hole are exposed to wear, and if this is done often the bolts will get loose and give trouble.

Much thought has been given to improvements on follower bolts, though it seems a simple thing to design some device that will hold a bolt securely in its place. But there always appears to be some drawback. This is why some engineers insist on a piston without junk ring, follower or bolts. If the piston is made long and lubrication is ample, it may give good results for a while, but eventually it will wear out of center and, not having any provision for adjustment, will give trouble; that is, of course, on horizontal engines. Pistons on vertical engines are not subject to wear and do not need any central adjustment.

An excellent but expensive method of securing follower bolts and nuts is shown in Fig. 15. It consists of a steel ring which is shown in cross-section. A dovetailed groove to correspond with the ring is turned into the face of the follower, the edges of the ring are made square in a number of places, and the groove in the follower is chipped out in the same number of spots, to register with the projecting parts of the ring. This will allow the ring to be inserted in the groove. It can then be turned around into such a position that the narrow parts will be over the follower bolts. A number of countersunk machine screws hold the ring in place. The upper part of the elevation in Fig. 15 shows the ring in position in the groove of the follower, while the lower part shows certain parts cut away at the edges. A number of engines on which the follower bolts gave considerable trouble were provided with rings as described.

Figs. 16 to 19 show different designs of junk rings for pistons. Fig. 16 shows the most approved way of arranging the junk ring, which is made in two parts—one turned to hold the packing ring and the other to fit into a recess in the first. The follower and piston hold the two parts of the junk ring firmly together. Adjustment is made by means of setscrews of tough bronze, with check nuts. The face of the two rings is lined with red metal strips hammered into dovetailed grooves and turned flush with the outside of the rings. This construction allows the removal and inspection of the packing ring by simply taking off the follower and the outer half of the junk ring; neither the adjusting screws nor the inner half of the junk ring have to be disturbed. Fig. 17 shows a modification of Fig. 16. The junk ring is made in one piece. If the packing ring has to be taken out and examined, the adjusting screws must be loosened and the whole junk ring removed from the cylinder. In Fig. 18 the junk ring covers only part of the piston, so that it is partly supported on its own rim and also on the follower. As the piston wears, the junk ring will have to be adjusted, and from that time on the weight of the piston will be supported by the much-reduced face of the junk ring. In this arrangement there are two packing rings used. The disadvantage is that if the second packing ring has to be examined or renewed the junk ring has to be removed. The construction is old and cannot be recommended. Fig. 19 shows a solid junk ring with two packing rings. All the objections to the design of Fig. 17 hold good in this case. There are many opinions about the design of the packing ring or rings, and there is a variety of them in use. It would seem that two rings in a piston would be better





FIGS. 20 TO 23. KEEPER AND PISTON-RING SPRINGS

Fig. 20—A simple keeper. Figs. 21 to 23—Showing methods of holding piston rings against the cylinder wall

and more economical in the use of steam than one, but practice shows this is not true. If the time taken to turn two grooves and make two rings is spent on one groove and one ring making perfect fit with about $^{2}/_{1000}$ in. clearance on the sides, one ring will be the more satisfactory. On horizontal engines the junk ring bears on the bottom half and it may be assumed that this part will be steam-tight, if properly lubricated. The only leak, then, that can occur is on the upper half; therefore, if the packing ring is made to fit well on the sides of the groove, so that no steam can get under the ring, all that is required to make it bear against the upper half of the cylinder is a slight pressure upward, and it appears that a snap ring will best perform this function, with the joint in the ring at the bottom. The ring may have the inner and outer surfaces turned concentric or eccentric and should be fitted with a certain amount of spring to make it exert a pressure of 2 to 3 lb. against the cylinder walls. The fit all around must be perfect, which means that it should be turned to the exact size of the cylinder after the joint has been made.

A simple keeper, as shown in Fig. 20, should be used. The joint in the ring is made by letting the two ends overlap. A strip of bronze is riveted to one end of the ring. If this strip is well fitted no steam will escape or get back of the ring and force it against the cylinder wall. Snap rings of this kind may be used with good results up to 30 in. diameter of cylinder. For larger sizes the ring may be made in two or more parts, using bronze keepers, as shown in Fig. 21, which in this form have a small projection at the back, over which a spiral spring slips. The object of this is to hold the parts of the sectional ring against the cylinder wall. Figs. 22 and 23 show the packing ring held out by steel springs. This is not considered good practice, as the tempered springs will break sometimes and the pieces work their way out and cut the cylinder.

[*The subject of the next article is Valves.*]

The Electrical Study Course—Some Mechanical Analogies

SYNOPSIS—This, the introduction to the electrical study course, compares the generation and flow of an electric current with the production of heat, light and sound and their flow through a conductor.

The object of this introduction is to give a clear conception of the electric current and its fundamental actions as used in commercial electrical machinery. It will be confined to a pictorial description rather than a mathematical analysis or study of the laws of electricity, because it will be easier for the student to understand the operation of the machinery that will be described later if a practical view is obtained of what is happening on the inside rather than to try to understand the results of laws or equations. Later, these fundamental principles will be referred to a great many times to get an insight of the actual workings of the different electrical machines, therefore it will pay the reader to get them firmly fixed in his mind.

Electricity is only one of several peculiar happenings in nature which are very common to us, but which are more or less mysterious. Sound, heat and light are in many respects similar in action to electricity, and on account of their being more easily understood it will be advantageous to compare a few of their actions. In each case there is a generating, a transmitting and a receiving apparatus. In each the product is invisible as it travels along the transmission system; consequently, what has happened must be judged from the effects produced.

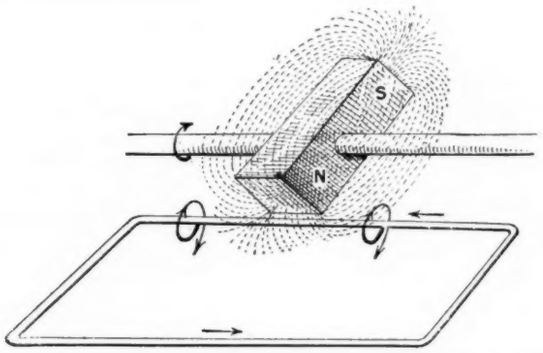
If a pencil is tapped on the desk, the contact generates a sound. This sound is transmitted in every direction along many paths from the point of contact. One path is through the air to the ear. The air is the transmission and the ear is the receiving apparatus. If an easier path having less resistance to the sound as it travels along is substituted, the listener will get more sound at the other end. For instance, if the ear is held to a railroad track and someone hits the rail a blow a half-mile away, the sound can be heard through the rail. It could not be heard through the air. The rail is the better conductor. It will also be noted that the sound cannot be seen as it travels along the rail or through the air. If the pencil is tapped on the desk with a greater speed, more sound will be transmitted to the ear than if tapped with a slow motion. There are two ways, therefore, of getting more sound—improving the conductor by using one of less resistance, and increasing the speed of the generator. This is similar to the conditions in an electrical generating system.

If one end of an iron rod is held against an emery wheel and the other in the hand, the emery cutting across the iron will generate heat, and the heat will flow along the rod to the hand. Thus we have a heat-generating system—a generating, a transmitting and a receiving apparatus. The emery wheel cutting across the iron is the generator, the rod is the transmission and the hand is the receiver. Here, too, the heat transmitted will depend upon the speed of cutting and the nature of the conductor. If a wooden rod is substituted, very much less heat will flow. If a vacuum is inserted in the line of transmission, practically no heat would flow across it; that is, it is an insulator to the flow of heat. It will be noticed in heat transmission also that nothing can be seen moving along the line of flow. Its effects must be dealt with, and it will be found that electricity is a close relative of heat and similar to it in some respects.

Light also has many characteristics that are similar to electricity. When the filament of an incandescent lamp is heated to a certain temperature, it begins to send out light. The light is transmitted along a line to the eye. It travels at a very rapid rate, much faster than heat or sound. Electricity travels at even a faster speed than light. As light travels along lines in space, it is also invisible to the eye. It is only when the end of one of these lines reaches the eye, either direct or reflected, that

the light is detected by the eye. This is clearly shown by the moon. At night the space around the moon is full of light rays, or lines of light from the sun, but it is only those lines that strike the moon and are reflected to the eye that give the sensation of light. The other lines of transmission of light are invisible and the passage of light along them cannot be seen.

Electricity is in several ways similar to these phenomena of heat, sound and light. It is invisible and for that reason we must use our imagination and be governed by its effects. It is not known exactly what it is, but that need not confuse the student, because there are other very common things in the same class. When the rod was held on the emery wheel, heat passed along the rod to the hand. We do not know exactly what it is that moves along the rod, but we know its effects. Light passing from the lamp must send something along the line to the eye. It is said to be wave motion and that no material substance actually passes. To make this clearer suppose a wire on a pole line is struck with a pair of pliers. This will cause a wave to travel along the wire to the next pole. It was the wave that went to the next pole and gave it a sensation, no material substance actually passed along the wire. That is the way light travels through space, but at a speed a million



ILLUSTRATING THE FUNDAMENTAL PRINCIPLE OF THE ELECTRIC GENERATOR

times faster. There is some sort of a vibration at the generator of light—a wave is sent along a line in space and finally reaches the eye and gives it a sensation similar to that which the pole received. Electricity is a similar action of the internal substance of the wire. Nothing actually passes, but as with light, heat and sound, we say it flows along the wire, which is the transmitting medium.

Electricity must, therefore, be studied from its effects, or rather, the effects of electricity must be studied, because they are, after all, what we deal with in all electrical machinery. As in the case of heat generating, take a simple example of an electrical generating system and study the effect in each unit part. By understanding the fundamental actions that occur in each part, the more complicated electrical machinery, which is simply an enlargement of these actions, will be simplified.

If a magnet is used in place of an emery wheel and a copper wire in place of the rod, we have an electrical generating system, as shown in the figure. A magnet (for our purpose) is a piece of steel that gives out magnetic lines of force. If this magnet is rotated so that the end passes across the copper wire, not quite touching it, and the magnetic lines coming out of the end of the magnet are cut across by the wire, electricity will be generated in the loop. The emery, by actual contact with the rod when cutting across it, generated heat in the rod. The magnetic lines, by actual contact with the copper wire when cutting across the latter, generate electricity in the conductor. In the first case it is said to be the friction of the particles of emery on the rod that generates the heat. In the second case it may be said that the friction of the magnetic lines cutting across the wire produces electricity. We do not use the word friction, however, because that is used in connection with heat generation. We say in electricity generation it is the induction of the magnetic lines cutting across the wire, but it means practically the same thing.

This, therefore, is the all-important principle to remember—magnetic lines cutting across a closed wire loop generate electricity. This action is made use of in generators, transformers, motors and in fact, all commercial apparatus except heating or chemical appliances. The magnetic lines are made to cut across wires by several methods, but fundamentally it should be remembered that the cutting action of the magnetic lines across the wire generates the electricity.

How Electric Pressure Is Varied in a Wire

The reader has probably noticed one thing in the sketch for electricity generation that is different from that of heat generation—a return path is shown from the receiving apparatus. This is necessary in electricity or the current will not flow. The cutting of the magnetic lines across the wire generates an electrical pressure tending to send the current along the wire, but no current will flow until the complete path is made. This electrical pressure is called voltage. If the magnetic lines cut across the wire at a very slow rate, there is not as much friction or induction, and the pressure, or voltage, is low. If the speed of cutting the magnetic lines is increased, the pressure or voltage is higher. The pressure is directly proportional to the speed of cutting.

If the number of the magnetic lines is decreased there will not be as much friction, or induction as it is called, hence, the pressure or voltage will be less; also, if the number of lines cut is increased, it will proportionally increase the voltage.

It may therefore be seen how a pressure, or voltage, is generated in the wire, which tends to send an electric current along the wire. The amount of current that will flow due to this pressure depends upon the resistance in its path. The amount of sound that came from the blow on the rail depended upon the resistance to the flow of the sound. Very little came through the air; most of it came through the rail. The rail had less resistance to the sound. The electric current will follow the path of least resistance in its endeavor to return to the generating point, and the amount of current, called amperes, that flows around this path will be governed by the resistance of the path for a given voltage. If the voltage is raised by speeding up the cutting or by increasing the number of lines, there will be more amperes flowing for a given resistance in the path. Therefore, the current depends upon two things—the resistance of the path and the pressure, or voltage, behind it. The voltage depends upon two things also—the speed of cutting the magnetic lines and the number of magnetic lines cut.

The current is now flowing along the wire. Let us consider the things that are happening in and around the wire while the current is flowing through it. It has already been said that electricity is closely related to heat. It is a peculiar fact that electricity flowing along a wire produces heat. The amount of heat produced will depend upon the amount of current flowing and the amount of resistance offered. If practically all the resistance is in one place, that part will get the hottest. Copper wire is used to conduct the current because it offers very little resistance to the flow. When it is desired to produce heat, as in a flat iron, a section of conductor is placed in the path which offers a high resistance.

A close relative of heat is light. The wire in the electric bulb, if heated by forcing an electric current through it, quickly becomes hot enough to send out light. Light waves go out from the wire, due to the heat, and the heat is due to the electric current passing through a high resistance.

Besides the heating effect, there is the chemical effect of an electric current, but on account of its very small use in commercial machinery, it will not be taken up at this time.

Magnetic Effect of an Electric Current

There is one other effect of the electric current—the magnetic effect. This is the effect from which all mechanical power from electricity is secured. As the current passes along the wire from the generator it sends out circular lines of magnetism around it. Electricity and magnetism are as closely related as heat and light. There may be heat without light and magnetism without electricity, but not light without heat, and similarly electric current cannot be had without magnetic lines. Whenever current is flowing in a wire, there are magnetic lines surrounding the conductor, and it is often for the sole purpose of getting these magnetic lines that an electric current is used. Except for heating, the magnetic lines surrounding the wire are what we are after in all electrical machinery.

When the path, or circuit, is completed in the simple generating system, the current flows and the magnetic lines spread out around the wire. When the circuit is opened, they close in and vanish. This will perhaps be made clearer by watching the hairspring of a watch. Let the shaft of the balance wheel represent the wire and the hairspring the magnetic lines that surround it. Let the tick of the escapement represent the opening and closing of the circuit. On one tick the circuit is closed, the current flows and the magnetic lines spread out around the wire. Another tick, the circuit is broken, the current stops and the magnetic lines close in. If the current is left on and is continuous in the same direction, the magnetic lines will spread out to a certain value and remain stationary as long as the current remains the same. Magnetic lines cannot be produced with pressure or voltage alone on the wire; the circuit must be closed and current flowing.

The number of lines surrounding the wire will depend upon the amount of current, or amperes, flowing. If the current in the wire is reduced, the surrounding magnetic lines close in, and if the current is reduced to zero, they do not immediately vanish, but close to zero gradually. If the current is increased, the magnetic lines spread out and more take the place of those spreading out. This spreading out and closing in of the magnetic lines is extremely important, because the motion of these lines is made use of in cutting across near-by wires. This action will be referred to a good many times in later lessons.

Nothing has been said as yet regarding the direction of current in the wire. This is important, because it governs the direction of the magnetic lines about the wire. Returning to the simple generating system, it will be seen that the ends of the permanent magnet are marked *N* (north) and *S* (south) pole. The magnetic lines are supposed to come out from the north pole of the magnet and return to the steel through the south pole. There will be a different effect produced in the wire when it cuts through the lines of force from the north pole than when through those from the south pole. One will induce a pressure tending to send the current around the loop in one direction, and the other will tend to send the current around in the opposite direction. That is, the direction of the current in the wire will alternate every time the magnetic lines from a different kind of a pole cut the wire. In other words, an alternating current is produced. Also, if the direction of the cutting is changed from upward to downward with the same pole, the direction of the induced current will be changed.

It is very important to remember that the direction of the current induced in the wire will alternate from two causes—one due to changing the direction of the magnetic lines and the other due to changing the direction of the wire across the lines of force.

There is no change in the heating effect due to the change in direction of the current. It is the same no matter in which direction the current flows. There is a change, however, in the magnetic effect. As the current starts in one direction, the surrounding magnetic lines start around the wire in a given direction and spread out as the current increases to its maximum value; then, as the current decreases to start in the other direction, the magnetic lines close in until the current becomes zero. When the current reverses, the magnetic lines go around the wire in the opposite direction and spread out as the current increases. To remember this change in direction, imagine a screw going into a hole. As the screw goes in the direction of the current, the threads will go around in the direction of the magnetic lines. As the screw is withdrawn with the current coming toward the observer, the threads will go around in opposite direction. This action is continually changing as the current goes in one direction, then in another. As the current changes direction, it does not chop off suddenly and go in the opposite direction. It decreases gradually to zero, changes direction, increases gradually to its maximum value, then decreases to zero again. This increasing and decreasing of the current is accompanied by an increasing and decreasing of the surrounding magnetic lines.

Some Cat—The Chicago "Sunday Tribune" is responsible for the following:

Vineland, N. J.—When the big engine at the borough electric power house was stopped this morning, there flopped from the flywheel what appeared to be a ball of waste, but it was alive, and the engineer finally identified it as the plant's pet cat. Kitty must have perched in the wheel for a nap while the engine was idle temporarily yesterday, and when it was started up nobody noticed her. All of yesterday and last night she clung to the wheel, which makes 150 revolutions a minute, and she must have had some trouble in holding on. The engineer estimated that pussy had traveled at least 500 miles in her giddy whirl.

It is doubtful if kitty experienced much trouble in "clinging" to the inside surface of the revolving flywheel.

Editorials

Languages for Engineers

Much has been written about what an engineer should study and read to improve his qualifications, but little attention has been given to languages. It is usually assumed that there are other things of more direct and immediate importance to a man studying to become an uptodate engineer than the knowledge of languages. To a great extent this has been true in the past, even though it is admittedly good for a man to know something of languages at any time. Today, however, much more importance attaches to languages than formerly, mainly because we are becoming a sort of center for the world's industry. There is perhaps a more important connection between engineering and the present propaganda for world trade than has yet been appreciated by the engineering profession. Among the first and important needs in this larger foreign field is power equipment, and along with this must go competent engineers to set it up and operate it. To do this right and to make the best of his opportunities, the engineer should be able to talk the language of the country to which he may be sent.

The popular inclination toward a study of Spanish is so general that in some of the larger cities the business men have inaugurated noon-hour classes for themselves, and in practically every city Y. M. C. A. schools, business schools and night schools of various kinds have been featuring Spanish and building up big classes among the young men and the young women, some of whom perhaps contemplate traveling in the South as salesmen, but others simply to qualify for handling the office work.

To the engineer of mature age who has settled down to his life's work this may seem merely a matter of general interest that does not touch him directly. While there may be room for some argument on this point, it is desired to point out more specifically the broader opportunity thus afforded the young man that contemplates taking up engineering; for wherever American capital is invested, whether it be in mining operations, the building of electric light and power plants, waterworks or manufacturing enterprises, there is likely to follow development that calls for power equipment and engineering.

While the Latin-American countries are the center of most of our attention at present and naturally lead the thoughts toward acquiring Spanish, there are other parts of the world that are worthy of attention in this connection. This is especially true of Russia, which perhaps has the biggest field of possible development to be found anywhere on earth.

Our Government is sending agents abroad to study certain commercial needs, and when a call is sent out for men to qualify for these missions, it invariably includes as one of the qualifications a knowledge of one or more languages in addition to English.

Surely, under such conditions considerable weight attaches to the study of languages when the prospective engineer is preparing to qualify for his calling.

A Glance Into the Future

In line with traditions of the season it is in order that *Power* take the readers into its confidence regarding just a few of the good things in store for them during the coming year.

A marked tendency in modern power plants, whether large or small, is greater use of electrical equipment. The operating man cannot hope to be conversant with all types of apparatus likely to be encountered in his work, but a thorough understanding of the fundamentals of electricity will enable him, with a little study, to comprehend the working of and intelligently operate such equipment. Moreover, new men are constantly coming into the field, and those older men who by experience are supposed to know often become rusty in the fundamental principles.

With this in mind and in response to a number of requests from readers, *Power* has arranged an "Electrical Study Course," which, beginning with this issue, will appear every other week. The paramount idea in preparing this has been to make it of greatest benefit to the operating man in solving his everyday electrical problems and also to lead to a better understanding of the various articles dealing with different phases of the electrical industry, which appear weekly in these columns.

Alternating with the "Electrical Study Course" will be a series covering "Steam Engineers' License Examinations." Instead of the hit-and-miss method of reproducing typical examination questions—a procedure of doubtful value to the man preparing for his examination—the series will thoroughly cover the ground upon which questions are usually based and will be replete with references.

Contemporaneously with these will be a collection of articles on "Steam Engine Troubles." These will cover points of good and bad design and should be of inestimable help to the man in the small or medium-sized plant.

For the men in the larger plants a series of articles, to be started a little later, on "Steam Turbine Operation" will be invaluable. This will take up the care and operation of the steam turbine, causes and remedies for vibration, balancing, lubrication, governing, adjustment of bearings and clearances.

Among other subjects of particular interest will be a number of articles on practical boiler-room operation, electric elevators and the installation of motors in accordance with the Underwriters' Rules, one of which appears in this issue. "Tom Hunter" is again with us, and many old readers will welcome his return. There will be several feature articles appearing in the near future, among which may be mentioned the new plant of the Buffalo General Electric Co., which contains many advances over present practices. This article will contain a symposium in which many distinguished engineers, representing the executive, consulting, designing and operating branches of the art, express what they believe the future holds for higher boiler pressures and superheat.

The present condition of the coal market, with its changing and exorbitant prices, is a matter seriously af-

fecting the power-plant manager and engineer. For this reason *Power* has instituted a new department giving weekly coal prices in various localities. In addition to this weekly service there will appear once a month a page devoted to current prices in power-plant supplies, such as, it is believed, the reader would like to keep posted on, but which would be impossible to gain from catalogs without the discount books. In publishing these we have endeavored to quote a fair average price on quantities which it would seem that a power plant might use, but no effort has been made to get the lowest possible prices. While the prices are not guaranteed, they are given just as quoted by a number of large dealers in this section.

A New University Service

Great prominence has recently been given to the subject of industrial preparedness, and much emphasis has been laid on the fact that this country must develop industrial leaders if it hopes to retain its present predominant position in the world's trade. Our business enterprises, in order to meet commercial competition after the war, must be directed by better-trained men than in the past, by men with broader viewpoints and higher educational advantages. Germany built up her industrial power largely by her educational methods. One is inclined to ask whether the educational institutions of this country are doing all that is possible in fitting the greatest number for the greatest service, although it must be admitted that the state universities in the West, with their extension courses, have done very creditable work along this line, and some universities and technical schools in the East have also been of great service.

Word now comes from Baltimore that Johns Hopkins University, widely known for its high-grade graduate and research work, has started night courses for teachers, for business men and women and for technical workers. This move was made on the initiative of J. E. Aldred, chairman of the board of directors, and his associates in the Consolidated Gas and Electric Company, of Baltimore. These men offered to guarantee any deficit, up to a certain sum, that might occur from the conduct of such night courses by the university. It was further stipulated that only a moderate fee should be charged students for each course. This offer was promptly accepted by the university. The Economics Department undertook the organization of the business courses, while the recently established Faculty of Engineering planned the technical courses. It is understood that the night courses will all be as nearly as possible of university caliber, so as not to overlap but rather to supplement the good work of the Polytechnic Institute and other night schools already giving elementary courses in the city.

This move on the part of the university has made a deep and favorable impression on the business interests of Baltimore that formerly looked on the university as a high-brow place of profound learning but of little assistance in everyday business life. The idea of university coöperation and service to the city has been so well received that several of the leading concerns have offered to pay half the fees of any employees who will take these courses and who satisfactorily complete the work.

The spirit of closer coöperation and helpfulness between industry and education as evidenced by the innovation at Baltimore, is most encouraging, especially when one considers the woefully inefficient use of the average college buildings and equipment.

Refrigeration Research by the Bureau of Standards

At the annual meeting of the Society of Refrigerating Engineers, three excellent papers were read by representatives of the Bureau of Standards. Papers of this character have been read at the last few annual meetings, giving the results and stating the progress of refrigeration research work carried on by the Bureau of Mines, in accordance with the program laid down five years ago with the assistance of the American Society of Refrigerating Engineers. These papers have dealt with the physical and chemical properties of ammonia, or more accurately, with anhydrous ammonia, and with heat-transmission research work as related particularly to insulation walls as used in refrigeration plants.

As in all such work, it was at the time thought that the amount appropriated for the carrying out of the program would be sufficient to see the work satisfactorily concluded, but development in the state of the art made it necessary in almost every case to carry the work on to a more thorough conclusion than had been anticipated at the time the program was laid down.

The Bureau of Standards needs money to carry on this work. With the growing importance of the refrigerating industry it is imperative that nothing stand in the way of carrying out the necessary research work—least of all money, considering that Congress seems to have little hesitancy about investing millions of dollars in "pork" wherein the people get as low as thirty cents on the dollar value invested. In this all too commercial country it is not always possible to get competent men to carry on the research work that our Government bureaus do. It is probable that the average American does not realize that private enterprise offers so much more in the way of pecuniary inducements to technical men of this character that it is at times, especially during these times, exceedingly difficult to get competent men for the more important work of the bureau.

We do not know if the director of the Bureau of Standards has asked for another appropriation, or whether he intends doing so, but we do know that ample funds should be allotted to this work. Congress should see to it that the bureau gets them.

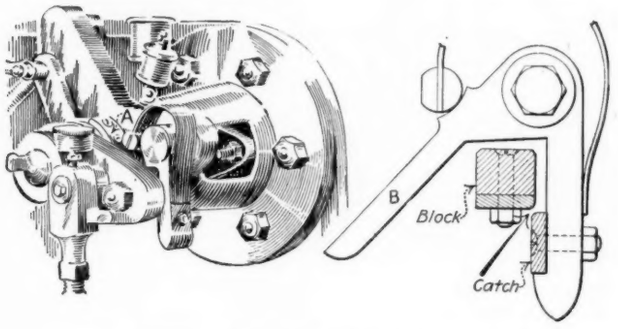
It is likely that to many the magnitude of the savings due to the utilization of waste heat from industrial furnaces, as stated by Arthur Pratt in his paper before the recent meeting of the American Society of Mechanical Engineers and abstracted in *Power*, Dec, 12, page 832, was a revelation. As pointed out, the utilization of this heat for steam boilers is a comparatively recent practice. Because of the enormity of the saving, one wonders why developmental work in this field was not begun many years ago and on the scale and of the wide scope described.

The index to volume 44 (the last six months of 1916) will be ready shortly and will be sent to all whose names are on the index mailing list. Those subscribers who received the last index are on the list. Any others who wish will be put on. A post-card request is sufficient.

Correspondence

Corliss Engine Speed Variation

The letter of L. A. Wilson in the issue of Nov. 28, page 764, reminds me of an experience I once had with a 36x42-in. engine with the same type of valve gear. One evening I observed that the speed had increased slightly above normal, and while investigating the cause,



INCREASED FRICTION CAUSED OVERSPEED

I felt a distinct trembling of one of the governor reach rods and found the cutoff cam *A* had become dry, which caused excessive friction each time the latch *B* engaged it. This rocked cam *A*, causing later cutoff and the excess speed. A few drops of oil on the cam brought the speed back to normal almost instantly. W. D. WAKEMAN.

Viscosity in Cylinder Oils*

In the Dec. 5 issue of *Power* Mr. Carpenter makes the amazing statement that his original letter concerning viscosity was intended only for the operating engineer. The editorial citation in parentheses from that letter does not support such a claim; persons do not debate "for the benefit of science" such technicalities as viscosity tests when they are addressing an audience of plant operatives, no matter how intelligent the audience addressed may be.

Again, in the third paragraph of the Dec. 5 letter, Mr. Carpenter indulges in another sidestep in trying to differentiate between the consumer and the man who supervises the selection of cylinder oils. If he had in mind as the "consumer" the man who pays the oil bills or the boy who fills oil cups, why write the letter at all?

In one breath Mr. Carpenter says "viscosity is viscosity, no matter how it gets there," and in another he says that the viscosity which he meant to call worthless is the viscosity produced by adulterants! The two statements are absurdly inconsistent.

It seems needless to discuss the difference between inherent viscosity and mere thickness due to fillers, but as Mr. Carpenter continues to insist that it makes no difference what gives oil its viscosity, please indulge me.

The inherent viscosity in cylinder oils is the property which holds the particles of oil together—adhesiveness, which tends to resist physical disintegration. This is what causes the oil to form a film over the surfaces to be lubricated, and to cling to those surfaces. This is a property of every known lubricant.

The viscosity due to adulterants is not oleaginous viscosity at all; it is mere thickness, and the substances which produce it have no value as lubricants. The viscosimeter, of course, cannot discriminate between the two, but it is quite a simple matter to detect that sort of adulteration by other means.

Mr. Carpenter's citation of the lubrication of internal-combustion engines is utterly inept. The conditions are not at all similar to those in a steam cylinder. If oil which worked perfectly in a steam cylinder were used in a gas-engine or oil-engine cylinder, the engine would have to be shut down in a short while because of inadequate lubrication and carbon deposits. In a gas engine the thinnest oil that has sufficient viscosity (please note) to form the necessary film is the best to use, because it has the lowest content of carbonaceous material. The oil is not subjected to the high temperature of the cylinder contents until it has done its work; then the remnant of oil on the cylinder walls is burned. In a steam engine, on the contrary, the object is to have a given charge of oil remain on the cylinder and piston rubbing surfaces as long as practicable; the higher the viscosity the longer will a given "dose" of oil remain—within reasonable limits. When the viscosity is higher than necessary, as it may readily be in the low-pressure cylinder of a compound or triple-expansion engine, the loss due to the internal friction of the oil itself and its higher price overbalances whatever advantage might be realized from the high viscosity.

Mr. Carpenter says that not 1 per cent. of the laboratories available to the operating engineer are competent to discover artificial viscosity. Allow me to supply this distressing deficiency in the engineer's resources. Any engineer who finds it necessary or desirable to test his oil for filler can do so very cheaply as follows:

Dissolve 10 c.c. of oil in 15 c.c. of gasoline of 86 deg. specific gravity (Baumé) and divide the mixture in two parts, approximately equal. Add to one of these three-fourths of its bulk in absolute alcohol, shake vigorously and allow to stand an hour. Add to the other gasoline and oil mixture about 20 drops of a saturated solution of stick phosphoric acid in alcohol, shake and allow to stand. In the first case, any precipitate will indicate rubber filler. In the second, a precipitate will indicate soap of some kind; it may be oleate of aluminum, or a potash soap, or magnesia or sodium. It matters not what kind it is, its presence is a fraud and a detriment.

A saturated solution of phosphoric acid is merely absolute alcohol containing as much stick phosphoric acid as it will dissolve.

One more point. Mr. Carpenter states that "at 500 deg. F. every possible cylinder lubricant will show practically

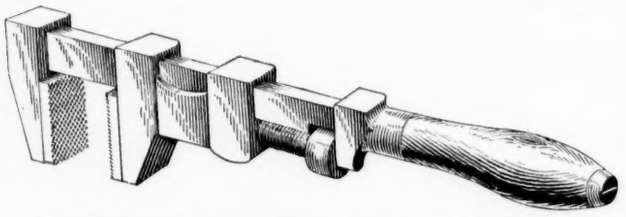
*For previous discussion, see "Power," Apr. 11, May 16, May 30, June 20, July 18, pp. 101 and 108; Aug. 1, Aug. 15, three letters; Sept. 26, Oct. 24, editorial, p. 595, letter, p. 598; Oct. 31, two letters; Nov. 14; Dec. 6, p. 789, editorial, p. 791, letter.

the same viscosity." He may be interested to know that three samples of oil submitted for use in a high-pressure cylinder and tested a few months ago showed respectively 90, 125 and 145 at 450-deg. temperature. These were not absolute viscosities, but the values were obtained with the same nozzle and under exactly the same viscosimeter conditions, with an instrument of the Tagliabue type.

CECIL P. POOLE.
Atlanta, Ga. City Mechanical Engineer.

An Emergency Pipe Wrench

A construction gang putting up a small boiler and engine in a country creamery plant were hampered to some extent because part of their tools (including all



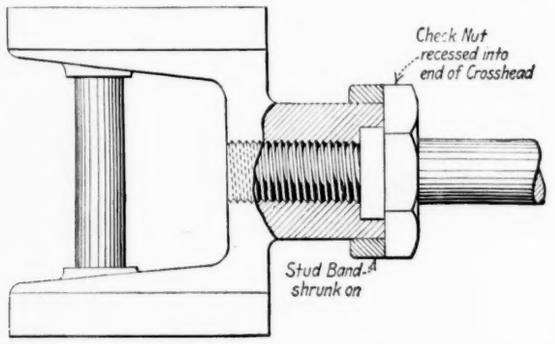
PIECES OF OLD FILE ON MONKEY-WRENCH JAWS

their pipe wrenches) had not arrived on the job. Since no other wrenches were available, they proceeded to make a pipe wrench out of an ordinary monkey wrench by soldering two pieces of an old rough file on each jaw of the wrench, as shown in the illustration. They used this for two days and did a good bit of work before the lost shipment turned up.

M. A. SALLER.
Philadelphia, Penn.

Piston-Rod Design

It is a fact that taper-ended piston rods keyed into the crosshead often break through the keyhole, especially with old engines that are carrying a higher steam pressure than they were designed for, and I have found during 40 years of engine-repair work that the best way to remedy this is



THREADED PISTON ROD SUBSTITUTED FOR TAPER

to cut a straight thread a little smaller than the piston rod and, if the hub is not strong enough, to shrink on a steel band and recess the check nut into the hub so as to get room to keep it from striking the gland. This makes a strong job that will hold as long as the rest of the engine.

L. L. GRAVES.
Streator, Ill.

Combination Soldering Tool

While the importance of soldering wire splices and ends of stranded wires is realized by most electrical workers, the work is often neglected from the lack of proper

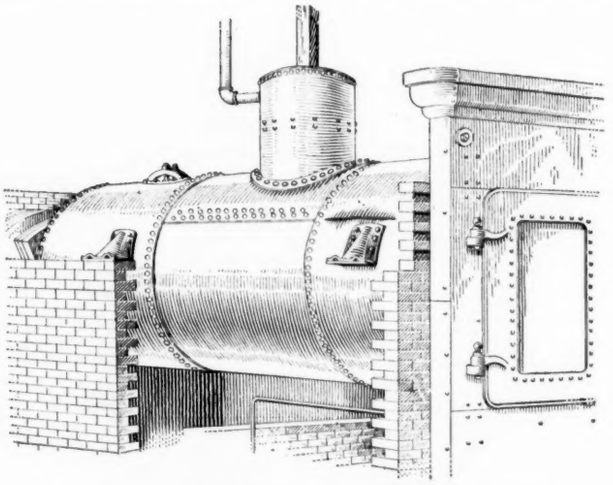
SOLDERING COPPER FOR SPLICERS

tools for doing it easily. A handy tool for this and similar work may be made by filing grooves in two of the working faces of an ordinary soldering copper. With a three-cornered file cut a groove about $\frac{3}{16}$ in. deep across one face and a similar one lengthwise of the other face. By running one of these grooves along the wire, it is much more readily tinned and soldered than with a flat-faced tool, and the solder does not roll off the work. Ends of wires, etc., may be very conveniently tinned by dipping them in the miniature ladle of melted solder formed by drilling a hole about $\frac{1}{4}$x$\frac{5}{8}$ in. in one side of the copper and running it full of solder.

Jersey City, N. J. I. S. CHAMBERLAIN.

A Freak Boiler "Repair" Job

Many odd defects develop in different types of boilers, although most of them can be classed as common. They are almost invariably caused by abuse of some nature, as most of us that have had extensive experience know, and



TIMBER PROP TO HOLD TOP OF DOME DOWN

the mode of repairs and methods used to overcome these defects are as varied as the defects themselves. One such case came to my attention recently.

The boiler was in the basement of a large building and was 66-in. by 18 ft. and had a 36x36-in. dome with a flat head $\frac{7}{16}$-in. thick held by 2x2$\frac{1}{2}$-in. welded braces attached to the dome in the usual manner with two rivets in the palm and crowfoot. The braces in the dome were all broken, and the engineer had wedged a 4x4 oak scantling from the top of the dome to the timbers of the floor above to keep the head from bulging up, as it naturally

would after the braces were broken. There was a force equal to the area of the head to be braced times the steam presure (100 lb.) besides the initial load that had to be supported by the four boiler-supporting brackets, and the result was that a crack developed 14½-in. in a longitudinal plane 2 in. above one of the front brackets and it had started to leak.

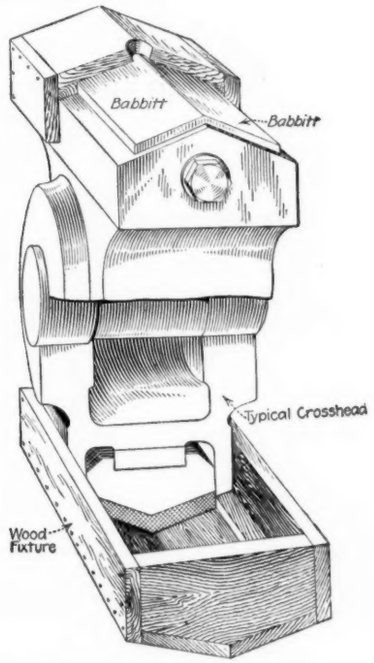
The engineer explained that the first brace broke about ten years ago and he had made "repairs" (as he called them) on the suggestion of the owner, as new braces would cost too much; besides, they could not shut down at that time.

One would wonder why a successful business man would not do the proper thing in the first place—call an experienced man in to investigate and then follow his instructions. As the average business man knows very little about boilers and engineering in general, he should consult his engineer from time to time as to the condition of the plant to attain the best possible results, which after all is what counts. E. WOTRING.

Evansville, Ind.

Babbitting a Crosshead

Machinists in the repair business often get the job of rebabbitting an engine crosshead—a job calling for no little skill to say the least. Sometimes the babbitting is done with the crosshead in position, and this method has



FORM FOR BABBITTING CROSSHEAD

the advantage of easy lining up in the proper position, but has against it the poorer wearing surface when there is no surplus babbitt to take off. "If it didn't slope off both ways, I'd pour it and plane it to fit," says the man who has the job to do. By the use of a simple form or fixture, that anyone can make in a half-hour, flat V-shaped or half-round crossheads can be poured in short order with any desired surplus of metal evenly distributed. This surplus may be peened to make it more dense and better fitting, and then turned or planed to size. The fixture is made of wood, as shown in position to use. It is made a snug fit over the crosshead, and the ends correspond to the shape of the engine guides. Fitting thus, no leveling is required. The babbitt is poured through the hole in the top. DONALD A. HAMPSON.

Middletown, N. Y.

Excess Air in Coal Combustion

I have read the article on "Excess Air in Fuel Combustion," by Morgan B. Smith, in the issue of Nov. 14, and would call attention to what seems to me some rather ambiguous statements. Mr. Smith says:

> In Fig. 6 are shown the results of proper regulation of temperatures compared with previously existing conditions. This is the case where fires were not kept hot and where the stack gases were needlessly low in temperature. By running the fires much hotter the gases to the stack were raised about 200 deg. in temperature, yet the boiler output was greatly increased. Before the change in operation the boiler surfaces were absorbing little heat; after the change they did so much more work that the increased loss to the stack was more than offset by the increased steam production.

I would inquire of Mr. Smith how he intends to keep a fire hot. It is evident that, with a constant calorific value for coal and with a constant percentage of excess air, the fire temperature will at all times remain constant, assuming the initial temperature of the air constant before reaching the fire.

The only way that the temperature of the fire may be increased is by reducing the percentage of excess air and still properly burning the coal, or by preheating the air before the coal is burned.

In other words, a properly operated boiler may maintain as hot a fire at a comparatively low rating as it may at a higher rating—indeed, usually a hotter fire, as the fuel bed is nowhere nearly as thick and better combustion may be obtained.

Assuming, therefore, proper combustion—that is, no CO and a high percentage of CO_2, or small excess of air—the fire temperature will be constant and the exit-gas temperature will be lower at the lower ratings of the boiler, and higher at the higher ratings.

Fire temperatures are the result of CO_2 conditions, or the percentage of excess air. At the uptake of the boiler, temperatures are the result of the rating at which the boiler is run, or the condition of the tube surface; also, of course, the steam pressure. F. B. ALLEN.

Pittsburgh, Penn.

Water in Exhaust Caused Wreck

The exhaust of a 17x17 engine had been used to heat a building some 200 ft. from the plant. The usual back-pressure and atmospheric-exhaust valve was provided, beyond which there was an oil separator, then a gate valve to connect to the 8-in. heating line in a trench. The separator drain, a 1½-in. pipe having a U-bend to form a seal, emptied into a small iron tank in a condenser pit near-by.

After a time the engine was used only as an emergency unit in case of accident to one of the condensing engines, but no changes were made in the piping except to close the gate valve and remove the weight from the back-pressure valve. It was the custom to turn the engine over occasionally in order to keep it in good condition, but one day several years later, when this was being done, the

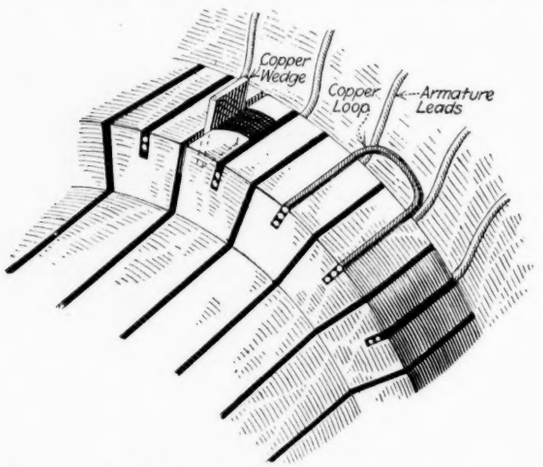
engineer heard a snapping sound, and not being able to locate it, he closed the throttle, whereupon the engine stopped with a heavy thud, water squirted from the cylinder-head joint in a shower, and the engine rebounded, turning in the reverse direction. An investigation showed that the end of the drain pipe from the oil separator had become plugged with mud and allowed the old 8-in. line to fill with water from the heating system through the gate valve. When the steam was shut off from the engine, a partial vacuum was formed in the cylinder and a quantity of water was drawn in. It was found that the crank disk had been pulled 1/8 in. over the end of the shaft, and twisted around 3/16 in. shearing the key, and the piston was driven onto its rod over 1/8 in. In making repairs the key was drilled and tapped to permit its being drawn out. Several days were spent in fruitless attempts to remove the crank disk, using every means at hand, with no result. It was then decided to drive it back, which was done by using a telegraph pole as a battering ram, after blocking the other end of the shaft solidly. The disk was driven on quite easily, and a new key was fitted and driven home.

After a new piston rod was put in and a few minor adjustments to the valve gear were made, the engine ran about as well as ever. To avoid another accident the old 8-in. line was disconnected at the exhaust riser.

Del Monte, Calif. A. C. McHugh.

Emergency Armature Repairs

Occasionally the engineer is confronted with emergency repairs on armatures in the nature of a burnt-out or open coil in the winding. Any delay in repairing these defects would be a serious matter, especially if the machine in question is an exciter and the only one for the alternator, as is the case in some of the smaller plants.



METHOD OF REPAIRING OPEN CIRCUITS IN AN ARMATURE COIL

The illustration shows a method used to facilitate the repairs of open coils with excellent results. The general method of procedure for the repair is as follows: First clean out the mica between the segments where the trouble has been located, by means of a hacksaw blade, to a depth of about 3/8 in., depending on conditions, taking care to clean the space thoroughly and free from mica, so that good electrical contact may be obtained between the segments. Second, make a wedge as shown. This can be made from a piece of 1/16x1/4-in. copper, or it can be made by flattening out a piece of No. 4 B. & S. gage copper wire of such thickness that the entering edge is slightly greater than the excavated space between the segments. The wedge is then driven between the segments until a good fit is made and the excess of metal filed down until the wedge is flush with the commutator. Then with a center punch or a small cape chisel slightly upset the commutator bars directly over the wedge so that the bars will grip the wedge firmly and at the same time eliminate any possibility of the wedge flying out by centrifugal force.

Another method equally as good, if the time element is a secondary consideration, would be to bend a piece of copper wire into a U-shape and solder it to the two segments between which the defect is located, as shown in the illustration.

In case of a short-circuited coil the same repair is used, but the defective coils must be cut in two. This can generally be best done at the back end of the armature near the core. When repairing an open circuit, it is good practice to remove one of the leads of the defective coil from the commutator, as this will prevent a short-circuit of the coil if the open should happen to close again. Samuel Spagnola.

Brooklyn, N. Y.

Two Floats Instead of One

Because of an increase in our city water pressure, the float-controlled regulating valve to the makeup-water tank was giving unsatisfactory service (leaking) and it was decided that a greater operative power was required,

TWO SMALL FLOATS CONNECTED TOGETHER

and a larger float than the 5-in. round one then in use. As the float was in good condition, and a larger one would cost about twice as much as another smaller one, the old float was unscrewed from the end of the rod and connected with a new one to the rod by a tee and nipples, as shown, and arranged so that both rested on the surface of the water. M. A. Saller.

Philadelphia, Penn.

Tendency of Lubricating Oil to Gum—An objectionable characteristic in some oils is the tendency to become resinous with use, and undergo the process of oxidation. This indicates, to some extent, the refining process the oil has undergone. A simple test can be made by placing a small quantity of oil in a glass beaker with nearly an equal amount of nitric acid, and should the oil be free from this objectionable character, the acid and oil will combine and get very thick, otherwise the oil will remain thin.

Inquiries of General Interest

Objection to Placing Pipes Within Steam Space—Why is objection made to placing a pipe within the steam space of a boiler? J. L. T.

Such a pipe, if of small size, may become completely stopped up by corrosion, or may become rusted through and, part of the pipe falling to the bottom of the boiler, may obstruct the blowoff.

Power-Limiting Reactances—Why are power-limiting reactances built without iron cores? N. O. C.

Current-limiting reactances, such as are used to limit the power that may be delivered into a short-circuit, usually are designed for from 3 to 10 per cent. reactance with normal current flowing. Under such conditions the magnetic density is so low that iron cannot be used satisfactorily in the magnetic circuit.

Effects of Change in Frequency on a Watt-Hour Meter—What effect will a change in frequency have on a watt-hour meter? R. A. B.

The effect will depend upon the type of meter. Certain types will run slow, while others will decrease in speed with an increase in frequency. Others will run fast for the first 5 or 10 per cent. increase in frequency and then decrease in speed if the frequency is increased beyond this point. However, the increase or decrease in speed for any well-designed meter is very small for considerable variation in frequency.

Central-Station Power of the United States—What is the horsepower capacity of central electric-light and power stations of the United States? H. J. J.

According to the census of central electric-light and power stations and street and electric railways for 1912, by the Bureau of the Census, Department of Commerce, made for 1912, there was a primary power capacity of 11,193,699 hp., of which 8,116,086 hp. was developed by 10,108 steam engines and steam turbines, 135,225 hp. developed by 1,164 gas and oil engines and 2,942,388 hp. developed by 3,316 waterwheels. These have, of course, materially increased since this report was made.

Setting Back Bag in Boiler Shell—When a bag forms in the under side of a boiler shell, how is it set back? J. L. T.

A hole the size of a rivet is drilled in the center of the bag, and the bulged-out portion is then heated to a bright-cherry heat with a gas flame or portable forge fire, and the bag is forced back with pressure from a screw jack, or a yoke is rigged for resisting the pressure from the screw. Pounding in place of screw pressure is sometimes resorted to, but it is likely to produce kinks and hammer marks that are difficult to remove. After the main bag has been set back, the surface of the boiler shell is faired up by swaging, backed by a heavy dolly or holdback placed inside of the boiler. The hole drilled in the bag permits the projection to be reduced easier and truer and is readily filled with a rivet.

Leaks at Pipe Joints from Changes of Temperature—In the steam plant of a factory where new pipe connections have been taken off from time to time, considerable trouble is experienced with leaks at joints, and more especially after shutting down for a day. How can the trouble be remedied without renewing the piping system? W. L. D.

Undoubtedly the system is in a condition that does not permit of freedom of expansion and contraction for changes of temperature. Less trouble will be experienced if the piping can be kept hot all the time. The remedy is to provide anchorages, supports and expansion members so arranged that the joints will be disturbed as little as possible from the alternate action of expansion and contraction.

Measuring Coal and Water in Boiler Test—In making an evaporative test of a boiler for determining its economy or capacity, is it necessary to weigh the water and fuel, or may they be estimated by other methods? W. A. N.

The principal elements to be obtained in a boiler test are the weight of water evaporated and weight of the fuel required to produce such evaporation. For accurate work the water, as used, should be weighed or else should be measured in tanks whose capacities, as employed, have been carefully calibrated by actual weighing. Water meters, as a rule, should only be used as a check on other measurements. A good method is to supply two tanks arranged so that they can be filled and emptied alternately. For large operations and continuous feeding three tanks are necessary: a lower tank to pump from and two measuring tanks, one of which is filled while the other is being emptied. The coal should be actually weighed out in small lots, preferably as used, and with no greater quantity available for firing than necessary for the continuous conduct of the test, and to avoid errors the tallies of water should be made when each measuring tank has been emptied, and tallies of the coal should be made when it is delivered to the fireman.

Power of Compound Engine—What is the rule for computing the power of a compound engine? D. T.

The power will be the sum of the horsepowers of each cylinder computed separately by the usual formula,

$$\text{I.hp.} = \frac{\text{PLAN}}{33{,}000}, \text{ wherein}$$

I.hp. = Indicated horsepower;
P = Mean effective pressure;
L = Length of stroke in feet;
A = Area of piston in square inches;
N = Number of single strokes per minute;
33,000 = Foot-pounds per minute in one horsepower.

But where, as usual, the length and number of strokes are the same in each cylinder, it is convenient to refer the mean effective pressure of the high-pressure cylinder to the low-pressure cylinder and, by adding it to the mean effective pressure of the low-pressure cylinder, take the sum as the mean effective pressure of the low-pressure cylinder and consider the power of both to be developed in the low-pressure cylinder.

The mean effective pressure of the high-pressure cylinder referred to the low-pressure cylinder will be equal to the mean effective pressure of the high-pressure cylinder multiplied by the area of the high-pressure piston and divided by the area of the low-pressure piston; or the mean effective pressure of the high-pressure cylinder multiplied by the square of the diameter of the high-pressure piston and divided by the square of the diameter of the low-pressure piston; or the mean effective pressure of the high-pressure cylinder divided by the ratio of the cylinders.

Boiler Horsepower Required to Heat Water—What number of boiler horsepower would be chargeable for heating 10,000 gal. of water per hour from 54 deg. F. to 150 deg. F. in a closed heater with the steam at 5 lb. pressure and the water under 60 lb. pressure? E. L. J.

A gallon of water weighs 7.48 lb., and 10,000 gal. would weigh 74,800 lb. To raise the water from a temperature of 54 deg. F. to 150 deg. F., each pound, regardless of its pressure, would require 150 — 54 = 96 B.t.u., and the heat required would be 74,800 × 96 = 7,180,800 B.t.u. per hr. A boiler horsepower is equivalent to the evaporation of 34.5 lb. of water per hour from and at 212 deg. F., and as each pound so evaporated would require 970.4 B.t.u., or the latent heat of evaporation at 212 deg. F., a boiler horsepower is the development of 34.5 × 970.4 = 33,479 B.t.u. per hr., and transfer of heat would be required at the rate of 7,180,800 B.t.u. ÷ 33,479 B.t.u. = 214.48 boiler horsepower.

The output of boiler horsepower required to realize the boiler horsepower to be transferred would depend on the latent heat of the steam, the losses from radiation of heat and the amount of heat returned to the boiler in condensate, provided its temperature is not below what otherwise would be the temperature of the boiler feed water without cost. The latent heat of steam at a pressure of 5 lb. gage, or 20 lb. per sq.in. absolute, is 960 B.t.u. per lb., and neglecting condensation from losses of heat by radiation, the transfer of 7,180,800 B.t.u. per hr. to the water would require 7,180,800 ÷ 960 = 7,480 lb. of steam. The total heat of steam at 5 lb. gage, or 20 lb. absolute, is 1,156.2 B.t.u. above 32 deg. F., and assuming that the condensate is returned and is to be credited with a temperature of 200 deg. F. then each pound of condensate for reconversion into steam would require 1,156.2 — (200 — 32) = 988.2 B.t.u., and to generate 7,480 lb. of steam under the conditions would require 7,480 × 988.2 = 7,391,736 B.t.u., or at the rate of 7,391,736 ÷ 33,479 = 220.78 boiler horsepower.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Low-Temperature Compression System*

By Harry Sloan

SYNOPSIS—Multi-stage compression opens up possibilities of appreciable saving in power consumption, size of low-pressure cylinder, etc., for low-temperature work. The advantages to be had are quite fully discussed.

In the past the ammonia compressor has not been advocated for low refrigerator temperatures, and when these conditions were to be met, it was generally conceded that this was the field for the absorption type of machine. Recently, more careful consideration has been given the matter and the causes of the uneconomical operation of compressors carefully analyzed. The first glance at a comparison of the capacity and power requirements of a compressor when operating under different suction pressures is discouraging for its use where the circumstances demand low suction pressures. Assuming a discharge pressure of 175 lb. from a standard simple ammonia compressor, the following table shows the relative capacity and power requirements as the suction pressure is changed:

Discharge Pressure, Lb. Gage	Suction Pressure, Lb. Gage	Horsepower	Refrigerating Capacity
175	20	1.00	1.00
175	15	0.96	0.85
175	10	0.90	0.70
175	5	0.82	0.55
175	0	0.72	0.40

The table shows that as the suction pressure is lowered there is a marked decrease in the capacity of the compressor without a corresponding diminution in the power requirements, which means useful work at a greater cost. These facts have long been recognized and have been regarded as insurmountable and of sufficient weight to bar the use of compressors for low-temperature work. The comparison also indicates that the cost of equipment would be excessive, owing to the large displacement required to produce a unit of refrigeration. For example, it will be noted that if the capacity at 20 lb. gage suction pressure is assumed as unity, then at zero pounds gage suction there will be a loss in capacity of 60 per cent. It will also be observed that the power required has been reduced only 28 per cent.

In going into the matter still further it is not hard to find a reason for these unfavorable conditions to the operation of the compressor. A pound of ammonia vapor occupies a space of 17.87 cu.ft. at 14.76 lb. absolute, or about zero gage pressure, while at 20 lb. gage pressure the volume per pound is only 8 cu.ft.

The volumetric efficiency for a compressor operating with 20 lb. gage suction pressure and 175 lb. gage discharge pressure is 82.37 per cent., and calculated on the same basis for zero pounds suction pressure and same discharge pressure, the volumetric efficiency drops to 72.52 per cent. The volumetric efficiency is largely governed by the temperature of ammonia vapor after compression. The higher the temperature of the compressed vapor, the higher will be the temperature of the cylinder and compressor parts and more heat imparted to the vapor entering the cylinder, which will lower the volumetric efficiency, owing to the increased volume of the vapor per unit of weight. It will be interesting to observe what the difference in discharge temperature amounts to for 20 lb. gage and zero pounds gage suction pressure and 175 lb. discharge pressure. Using the formula,

$$T_1 = T_2 \left(\frac{P_1}{P_2}\right)^{0.24}$$

where T_1 equals the absolute temperature of the discharge, T_2 equals absolute temperature of suction and P_1 and P_2 corresponding absolute pressures, the discharge temperature for 20 lb. gage suction pressure will be 240 deg. F. and with zero pounds gage suction pressure the discharge temperature will be 340 deg. F. (The charts of Goodenough and Mosher show 230 deg. and 320 deg. for these conditions.) These temperatures may be somewhat lower in actual operation, but the relative values are correct.

There is still another important factor having an indirect bearing on this subject; that is, the low temperature to which the liquid ammonia must be reduced before doing useful work in the refrigerator. Provided that the liquid ammonia leaves the condenser, or rather reaches the inlet or expansion valve at 80 deg. F. (which is not unusual and in many instances it may be of a higher temperature), before this liquid is available for doing useful work it must be cooled to the temperature of the refrigerator. Now assuming a suction pressure of 14.76 lb. absolute, or about zero pounds gage, the refrigerator temperature will be 27 F., which means that the temperature of the liquid ammonia will have to be lowered 107 deg. F. in the refrigerator, and it will require approximately 118 B.t.u. to do this work. The latent heat of evaporation at 14.75 lb. absolute is 592.5 B.t.u., which leaves 474.5 B.t.u. per pound evaporated for useful work. In other words, 20 per cent. of the liquid passing the inlet valve is nonproductive and used for cooling the liquid. Each pound is evaporated into 17.87 cu.ft. of vapor, which must be handled by the compressor.

The object of the treatment of this subject up to the present point has been to bring out the causes of the limitations of the ammonia compressor for low-temperature work. It will be now undertaken to show, step by step, how each can be partly overcome. The possible gains in some of the disadvantageous features are small, while in others of more importance, but taken collectively, a very material saving can be shown.

POWER CONSUMPTION WITH MULTI-STAGE COMPRESSION

In the first place, the power requirements will be taken up and means for bettering this condition discussed. When ammonia vapor is compressed in a cylinder without removing any of the heat generated, there will be adiabatic compression, but if this heat could have been removed as produced, isothermal compression would have been the result. The latter is the impossible ideal, but if attained would result in a great power saving. It is a well-known fact that as the vapor is heated the volume is increased, and it is but reasonable to expect that the higher the heat of compression the greater will be the temperature rise in any given amount of vapor entering the cylinder, consequently the greater the volume. This will have the same effect as compressing a greater volume and increases the average pressure in the cylinder, both of which require an excess of power. This brings out the importance of keeping the heat of compression as low as possible. It is a common practice to water-jacket the cylinder and remove part of the heat through the walls of the cold cylinder, but because the vapor is a poor conductor of heat and a very small portion comes in contact with the cold walls of the cylinder, the function is imperfectly performed. Now imagine that the piston could be stopped at numerous points of the stroke and the vapor cooled to its original temperature. Then isothermal conditions would be approached and the compression accomplished with the least possible expenditure of power.

The nearest approach to these ideal conditions that is practical is by multi-stage compression. The saving of power by multi-stage compression for air, where pressures of above 80 lb. are required, is too well known to require discussion. Taking into account the differences in the heat of compression of air and ammonia, the latter has advantageous properties which cannot be applied to air compression, which will be referred to later.

The reduction in power required is accomplished in the multi-stage ammonia compressor by cooling the vapor to the temperature corresponding to the saturation point between the stages by the refrigerating medium. The volume of the vapor from the liquid required to do this cooling will amount to only a small percentage of the increase in volume due to superheat of the vapor being compressed were it not so cooled.

It has previously been shown that 20 per cent. of the liquid passing the expansion valve did not do useful work when operating under low temperatures. Multi-stage compression opens up possibilities of making very material savings in power, size of low-pressure cylinder, etc., due to this condition. The liquid is cooled as nearly as possible to the temperature corresponding to the suction pressure of the second stage, say from 12 deg. to 15 deg. F. The vapor from the liquid cooler is passed directly to the second-stage compressor. Under these conditions, the liquid not doing useful work in the refrigerator is reduced to from 5 per cent. to 8 per cent. instead of 20 per cent. of the total liquid evaporated, and the amount of rare vapor handled by the low-pressure cylinder correspondingly decreased. This latter feature is very important in decreasing the size of the low-pressure

*Read at the twelfth annual meeting of the American Society of Refrigerating Engineers.

cylinder, and it should be particularly noted that the saving in the refrigerating work of the low-temperature refrigerator is accomplished in the second-stage compressor under most favorable high suction-pressure conditions.

The temperature of the ammonia vapor after compression, assuming that from zero pounds refrigerator pressure the compression is carried to 20 to 25 lb. gage in the low-pressure cylinder, will be 70 deg. to 85 deg. F., when calculated by the same formula previously employed. In practice the temperature is always found to be somewhat lower than the theoretical determination, and a cool low-pressure cylinder will be assured.

With a simple compressor it was found that the volumetric efficiency was low when operating at 175 lb. discharge and zero pounds gage suction pressures, being only about 72 per cent. The volumetric efficiency for the low-pressure cylinder in multi-stage compression is very much higher. Assuming that the low-pressure cylinder takes the vapor at zero pounds gage from the refrigerator and discharges at 25 lb. gage, the volumetric efficiency will be 91.5 per cent. This is an important gain and shows that a much smaller cylinder will do the same work when compared to the simple compressor.

The higher volumetric efficiency of the multi-stage compressor is easily explained. In the first place all compressors have some clearance space, and the vapor remaining in this space must expand to the suction pressure before the intake valve will open to admit vapor from the suction line. In the simple compressor, where the vapor is compressed from zero pounds gage to 175 lb. gage, the piston must travel back to a greater percentage of the stroke before the suction valve opens than would be the case where a multi-stage compressor is employed having a terminal pressure at the first stage of only 25 lb. The second cause for higher volumetric efficiency is due to lower terminal temperature of the compressed vapor, which insures a correspondingly low cylinder temperature. Still another cause is due to the greater liability of vapor leakage, passed valves and pistons, owing to higher pressure differences in the simple compressor. In a steam-driven compressor a very economical arrangement is to have compound compressors and compound engines or a double cross-compound machine. The compound compressor reduces the maximum stresses on pins, frame, etc., at the terminal of the stroke, and the cranks set at 90 deg. secures a more uniform rotative effect and makes operation at low speeds more successful.

Wherever there is a transformation of energy, there will always be losses, but by a careful study of the nature of these losses, it is often found possible to reduce them to a minimum. In former refrigerating-engineering practice advantage has been taken of some of the features outlined. However, to be most successful they must be used collectively. If this is done, a saving of 25 per cent. in the indicated horsepower of the engine driving the compressor will be obtainable and will place the compression type of machine in an advantageous position to compete in economy with any system when used for low-temperature refrigeration.

The Gasoline Situation*

By Vannoy H. Manning†

In discussing the various problems involved in a consideration of the present gasoline situation, one must bear in mind that while the demand is steadily increasing, the production of crude oil, which is the raw source of the gasoline, is remaining approximately stationary, if it has not been declining in the last year. A year ago—in the early fall of 1915—gasoline was selling in some localities at 11c. a gallon owing to the tremendous production of gasoline-rich crude oil produced by the Cushing Field in Oklahoma. This production, however, has declined from over 300,000 bbl. of crude oil per day to less than 60,000 bbl. per day.

The Cushing crude contains from 25 to 30 per cent. of gasoline. The new production, which has compensated for the decline in the Cushing production, contains only from 15 to 17 per cent. of gasoline.

Notwithstanding the decline in the production of gasoline, the demand has steadily increased, primarily because of the increased use of the automobile. On Jan. 1, 1916, there were 2¼ million automobiles in use in the United States. Jan. 1, 1917, probably saw more than 3¼ million in use, while by 1918 there will be at least 4½ million machines used in this country. These figures, it should be remembered, refer to automobiles alone and do not include the increased use of motor trucks, farm tractors, stationary gasoline engines, motor boats, etc.

This increasing demand for gasoline has been met partly by the automobile engineers and refiners. The former have improved their engines and carburetors, making it possible to use heavier fuels in the automobile of today, which would have been impracticable a year or two years ago. The refiners, taking advantage of the work of the engineers, have been able to use heavier oils for gasoline, thereby increasing the percentage of gasoline obtainable from a given amount of crude oil. This has resulted in increasing the "end point" from 150 deg. C. in 1915 to an end point of 175 degrees to 200 deg. C., the figure of today. The end point is the temperature at which 95 per cent. of the gasoline will distill off if handled in a proper flask at the proper rate.

The Bureau of Mines recently purchased four samples of gasoline sold in the District of Columbia. These were analyzed and the end point determined in each instance. The gravity of one was 64.8; the gravities of the other three ranged from 61.5 to 62. The end point of the first sample was 210 deg. C.; the end point of the other three was 175 deg. The high end point of the first sample, together with its high specific gravity, indicates that this was a blended gasoline and this deduction is further substantiated by the analysis, which indicates that 21 per cent. is redistilled under 75 deg., whereas less than 10 per cent. of the other three samples is redistilled at this temperature. This larger proportion of light products, which is responsible for the high gravity, indicates that "casing-head" gasoline has been blended with the heavy distillate, because the end point of this gasoline is 210 deg., as against the 175 deg. for the other three samples analyzed. It is possible that this blended gasoline might prove satisfactory in some automobile engines.

The end point is important because it is a measure of the readiness of the gasoline to vaporize, information which it is desirable and necessary to have in selecting suitable fuel for gasoline engines. As a result, the refiners have been able to supply a lower-grade fuel, which is now adaptable to the improved automobile engine. This, of course, automatically has a tendency to keep the price of gasoline down; as it can readily be seen that if the standard of quality is higher the supply would be more limited and correspondingly more expensive.

GASOLINE BY THE CRACKING PROCESS

Refiners are coöperating along another line to the same end; namely, to increase the amount of gasoline and at the same time to keep the price down to a reasonable basis by means of "cracking" kerosenes and heavier oils, thereby converting into gasoline a certain proportion of the crude oil that was not formerly utilized for that purpose. In 1915 there was produced by the cracking process approximately 2,000,000 bbl. of gasoline; in 1916 it is estimated that more than 5,000,000 barrels were produced in this way. This is all the more striking when it is considered that these 5,000,000 bbl. of gasoline were made from oils which, in the past, did not enter into the making of this product, and it also indicates the possibilities of the present production of crude oil to supply the future requirements of the automobile.

The seriousness of the motor-fuel problem has been appreciated by the Bureau of Mines for a number of years; in fact, long before the sharp increase in the price of gasoline, this bureau was aware of the conditions and realized that this increase in prices would follow. It was at that time that the bureau began a serious investigation of this entire question. The special investigation bearing directly on the quality of gasoline was begun early in 1916 and is being continued today. Samples of gasoline were purchased in the open market (not from refiners) in all parts of the country and were analyzed by the experts of the bureau, while engine tests were also made with the representative grades of gasoline. The results of these investigations will be contained in an exhaustive and thorough report to be issued shortly by the Bureau of Mines. There is also in course of preparation a report on gasoline specifications, which will take into consideration the available supply, the increasing demand and the protection of the public, as well as fair treatment for the refining industry—all with the purpose of assuring a future of gasoline to the public at the most reasonable price possible.

One of the results that may prove startling to the public is that the gravity of gasoline does not of itself necessarily mean a satisfactory basis for the purchase of this fuel. The bureau conducted engine tests on gasoline having a gravity of from 74 to 60 deg. The net result of these tests showed a difference in power developed of less than 2 per cent. between the gasolines of the widely different gravities. This is all the more remarkable when it is considered that although 74-gravity gasoline is selling at 31c. per gal., the 60-deg. grav-

*Revised from an address before the Washington Retail Merchants' Association.

†Director of the Bureau of Mines.

ity gasoline may be purchased about 9 or 10c. cheaper. It also appears probable, from our tests, that the 60-gravity gasoline can be used in the automobile with the same satisfaction as the 74-gravity grade, thus effecting an immediate and considerable decrease in the price of fuel.

All gasolines can, under properly regulated engine conditions, be made to develop quantities of power that are not greatly different. This conclusion is the result of experimental work in our laboratories in Pittsburgh and indicates that the claim made by many refineries for the power-producing qualities of their gasoline are largely without foundation. It does not necessarily follow that all gasolines are equally good, but it is certain that exaggerated claims are made for the number of miles per gallon obtainable from the product of certain producers. The possible element of superiority undoubtedly lies in the quality some products have of giving maximum efficiency over a wider range of engine conditions. The important fact is, therefore, that if the user takes sufficient care of his engine, he can obtain almost as good results from a cheap gasoline as from an expensive high-test product.

Recently, owing to the remarkable development of the casing-head gasoline industry—that is, the obtaining of gasoline from natural gas—there has been obtained a product called blended gasoline. The casing-head gasoline is too volatile to be used directly. It is therefore mixed with oil just a little lighter than kerosene, but heavier than gasoline. Such a blended gasoline may be of any gravity desired by the manufacturer, but it is naturally different in composition and properties from the straight refinery product which it may chance to resemble in gravity only. This is due to the fact that it is generally composed of more of both the heavier and lighter oils than gasoline made by the ordinary processes. On account of the larger proportion of light oil, it is possible to use a correspondingly large proportion of heavy oil and still obtain an average gravity equal to that of ordinary gasoline. But this blend may act very differently from ordinary gasoline when used in an engine accustomed to the latter, on account of the large portion of heavy oil contained in the blended product.

This argument is not intended to discourage the use or manufacture of casing-head gasoline. If the casing-head product is blended with the proper oils—that is, oils that are not too heavy—it can be used satisfactorily in an automobile engine. Casing-head gasoline is an important addition to our fuel resources, the production amounting to approximately 5 per cent. of the total output of 1916.

The Bureau of Mines is now at work on gasoline specifications for the General Supply Committee of the Federal Government, which will undoubtedly be of interest to all users of gasoline. This will be equivalent to setting a standard for gasoline intended for Government consumption because, without a special act of Congress, the bureau would not be empowered to designate a certain grade to which all gasoline produced in the United States must conform. However, these specifications will show what the Government demands and, as a corollary, what the individual consumer has a right to expect.

In addition to standardizing gasoline for use in automobiles, the Bureau of Mines is also at work, in conjuction with the Curtiss aëroplane-manufacturing concern, in an effort to obtain a satisfactory gasoline for aviation use in Government aëroplanes. This, of course, will be a special gasoline intended for a particular use and not a grade in which the average automobile owner will be interested.

In obtaining purity in gasoline—a nation-wide movement in which the Bureau of Mines is very much interested and which we are endeavoring to assist in every possible manner—we must keep before us the fact that there should be the greatest possible use of the raw materials consistent with economic results. For example, no specifications should be drawn up that would exclude from use certain materials that are now being satisfactorily employed, for if these were eliminated, the supply would be correspondingly restricted and the price would rise automatically—conditions that are far from desirable. The Government is exceedingly anxious that all the available resources for the making of gasoline be used to their fullest extent, and it is also deeply interested in the encouragement of further economy in the design of the automobile engine. Any specifications that would restrict the use of some of the low-grade oil resources would at once stop any further efforts toward improvement in engine design. At the same time the Bureau of Mines is doing everything in its power to see that the public obtains a thoroughly satisfactory fuel.

To these ends, the entire facilities of the laboratories of the Bureau of Mines are at the disposal of the American public, and the officials of this bureau will take every possible step to secure a pure, high-grade, reasonably priced gasoline for the several million automobile owners.

Testing House-Heating Boilers

"The Testing of House-Heating Boilers" was the subject of a paper presented at the 1916 annual meeting of the A. S. M. E. by L. P. Breckenridge and D. B. Prentice. After being read, it was referred to the Power Test Committee, as the authors propose a standard method for testing this class of boilers which is a type of apparatus that has not as yet received the attention of that committee of the society.

The satisfactory testing of house-heating boilers by a method which admits of fair comparison is important for three reasons: (a) On account of the increasing cost of anthracite coal it is desirable to determine efficient types of heaters and the most efficient method of burning this fuel. (b) It is desirable to develop efficient types of furnaces for other fuels, such as bituminous coal and coke. (c) By means of standard tests it is desirable to establish a satisfactory rating system which will eliminate the uncertainty of the present manufacturers' ratings, these being seldom comparable and often optimistic.

The proposed individual code of rules for conducting evaporative tests of house-heating boilers, is to be used in conjunction with the First Section (General Matters) of the Report of the Power Test Committee and follows closely the A. S. M. E. Boiler Code of 1915, differing materially only in the paragraphs dealing with the duration of tests, the method of starting and stopping tests and the calculation of results.

In the last paragraph it is specified that the capacity of a boiler in "feet of radiation" served be found by dividing the total heat absorbed per hour by the water in the boiler, expressed in B.t.u., by 242.6 which is in accordance with the authors' new definition of the "foot of radiation," which is 0.25 lb. of steam condensed from and at 212 deg. F. per hr. The "foot of radiation" as usually employed is understood to be that surface which will condense 0.25 lb. of steam per hour at 2 lb. pressure when in still air at 70 deg. F., and its heat equivalent is 241.5 B.t.u.—practically that of the new definition.

The advantages of the new definition of the "foot of radiation" are stated to be as follows: (a) Both heating-boiler and power-boiler capacity units are based on the same physical conditions, and they are mutually convertible by the factor 138. (b) Radiation is rated without reference to surface, so that efficient designs and arrangements are benefited. (c) The unit is applicable to hot-water radiators and heaters by determining the heat transfer.

The authors recommend that radiator tests to determine rating be made with steam at 2 lb. pressure and in "still air" at 70 deg. F., and suggest that boilers under test be operated at 3 to 8 lb. pressure.

PERSONALS

R. J. Cory, who has been superintendent of the Valparaiso Lighting Co. for the past three years, is now manager of the company at Valparaiso, Ind.

H. W. Dowd, assistant sales manager of the Nordberg Manufacturing Co., Milwaukee, Wis., has succeeded F. W. O'Neil, resigned, as sales manager.

Fred W. O'Neil, for many years sales manager of the Nordberg Manufacturing Co., at Milwaukee, Wis., is now with the Ingersoll-Rand Co., New York.

Guy L. Bayley, who was chief of the mechanical and electrical departments of the Panama-Pacific International Exposition, has opened an office as consulting engineer in the First National Bank Building, San Francisco, Calif.

ENGINEERING AFFAIRS

The German-American Engineers' Association No. 29, N. A. S. E. celebrated its twenty-fifth anniversary with a ball and banquet on Saturday, Dec. 16, at Teutonia Assembly Rooms, New York City. At twelve o'clock the company marched from the ball room to the main dining hall, where a hearty dinner was served. Many speeches were made by prominent members of the organization. During the evening past national president William J. Reynolds presented the six surviving charter members of No. 29 with honor badges. The officers of the association are: Charles Busch, president; Henry L. Richtberg, vice-president; Alfred E. Moench, treasurer; Joseph Fleischner, corresponding secretary; Herman Gahre, recording secretary; Frank Heilman, conductor; Joseph Giersch, doorkeeper; Henry Hermans, labor secretary.

THE COAL MARKET

Boston—Current quotations per gross ton delivered alongside Boston points are as follows:

ANTHRACITE

	Circular		Individual	
	Dec. 27, 1916	One Year Ago	Dec. 27, 1916	One Year Ago
Buckwheat	$3.60	$3.10	$6.00@6 50	$3.00@3.50
Rice	3.10	2.50	5.50@5.75	2.60@3.00
Boiler	2.95	....	5.00@5.25	.....
Barley	2.85	2.25	4.20@4.60	2.45@2.60

BITUMINOUS

Prices per gross ton for Boston delivery:

	F.o b. Mines All-Rail Rate $2.60 to Boston		Alongside Boston Water Coal	
	Dec. 27, 1916	One Year Ago	Dec. 27, 1916	One Year Ago
Clearfields	$4.75@5.75	$2.50@3.25	.....	.....
Cambrias and Somersets	.....	2.85@3 25	$8.40@9.25	.....
	F.o.b. Hampton Roads		On Cars, Boston	
	Dec. 27, 1916	One Year Ago	Dec. 27, 1916	One Year Ago
Pocahontas and New River	$7.25@8.00	$2.85	$9.50@10.00	$6.00@6.25

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports are as follows:

ANTHRACITE

	Circular		Individual	
	Dec. 27, 1916	One Year Ago	Dec. 27, 1916	One Year Ago
Buckwheat	$2.75	$2.75	$5.25@5.50	$2.47@2.75
Rice	2.20	2.25	4.25@4 50	1.95@2 25
Barley	1.95	1.75	3.45@3.70	1.50@1.75

Quotations at the upper ports are about 5c. higher.

BITUMINOUS

	South Amboy		Port Reading	Mine Price	
	Dec. 27, 1916	One Year Ago	Dec. 27, 1916	Dec. 27, 1916	One Year Ago
Clearfield	$7.50@7.75	$3 90@4.15	$7.50@7.75	$5.50@6.00	$2.25@2.60
South Forks	7.75@8.00	4.05@4.30	7.75@8.00	5.50@6.00	2.50@2.75
Somerset	7.50@7.75	3.75@4.15	7.50@7.75	5 50@5 75	2 00@2.75
Nanty Glo	7.75@8.00	4.05@4.30	7.75@8.00	5.50@6.00	2.50@2.75
Quemahoning	7.75@8.00	3 75@4.15	7.75@8.00	5.50@5.75	2.00@2.75

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Dec. 27, 1916	One Year Ago	Dec. 27, 1916	One Year Ago
Buckwheat	$2.00	$1.50	$2 90	$2.25
Rice	1.25	.85	2.15	1.75
Boiler	1.10	....	2.00	....
Barley	1.00	.50	1.90	1.25

Birmingham—Price pet net ton f.o.b. mines, Dec. 27, 1916:

	Mine-Run	Washed Mine-Run	Washed Nut
Pratt	$4.00@4.25	$4.50	$4.50
Big Seam	3.50@4.00	$3.75@4.25	$3 75@4 25
Black Creek	4 00@4.25	4.50	4.50
Carbon Hill	.....	4.00	4.00
Cahaba	4.00@4.25	4.50	4.50

Pittsburgh—Price of steam coal per net ton f.o.b. mine, Pittsburgh district:

	Dec. 27, 1916	One Year Ago
Slack	$3.50@3.75	$1.00@1.10
Mine-run 4	4.25@4 50	1 25@1 30
¾-in.	4.25@4.50	1.35@1.40

Add 40c. per ton for freight charge to Pittsburgh.

Chicago—Price pet net ton f.o.b. mines, Dec. 27, 1916:

	Springfield	Clinton and Sullivan Cos.
Steam Lump	$3.75@4.00	$3.75@4.25
Egg	3.75@4 00	3.50@3.75
Nut	3.75@4.00	3.25@3.75
Screenings	3.50@3.75	3.50@3 75
Mine-run	3.75@4.00	3.50@3.75
Screenings	3.75@4.00	3.75@4.00

	Williamson and Franklin Counties	Saline and Harrisburg	West Virginia Smokeless
Lump	$3.75@4.50	$3.75@4.25	$5.50@6 25
Egg	3.75@4.50	3.75@4.00	5.50@6 25
Nut	.....	3.75@4.00	.....
No. 1 nut	3.75@4 25	.....	.....
No. 2 nut	3.75@4.25	.....	.....
No. 3 nut	3.50@3.75	.....	.....
No. 1 washed	3.75@4.25	.....	.....
No. 2 washed	3.75@4.25	.....	.....
Mint-run	3.75@4 00	3.75@4.00	5.00@5.50

Hocking lump, $4; splint lump, $4.25

St. Louis—Price per net ton f.o.b. mine:

	Williamson and Franklin Counties		Mt. Olive and Staunton		Standard	
	Dec. 27, 1916	One Year Ago	Dec. 27, 1916	One Year Ago	Dec. 27, 1916	One Year Ago
6-in. lump	$3 50	$1.50	$3.50	$1.25	$3.50	$1.10@1.15
2-in. lump	...	1.35	...	1.15	3.50	.90@1.00
Steam egg	3.50	...	3.50	...	3 50	.....
Mine-run	3.50	1.10	3.50	1.00	3.50	.85@ .90
No. 1 nut	...	1.20	...	...	...	.90@1.00
2-in. screenings	3.50	.80	3.50	.75	3.50	.70@ .75
No. 5 washed	3.25	.80	...	.70	...	.70

Williamson-Franklin rate St. Louis, 72½c.; other rates, 57½c.

PROPOSED CONSTRUCTION

B. C., Vancouver—Council has purchased a site on Brifge River and will construct a large power and development plant. W. McQueen, clerk.

Iowa, Shenandoah—City voted in favor of proposition to construct an electric-light and power plant.

Iowa, Tipton—County Board is considering installing electric-light plant in new county home building.

Kan., Lenora—City is having plans prepared for an electric-light plant. About $10,000. G. P. Taylor, Stockton, engineer.

Kan., Quinter—City soon to vote on $15,000 bonds to construct an electric-light plant.

Ky., Covington—Kelley-Koett Co., manufacturer of X-ray apparatus, is having plans prepared for additions to its plant at 122 West Fourth St.

Ky., Paducah—City plans to enlarge its electric-light plant. F. N. Garns, mayor.

Mich., Grand Rapids—The Cascade Electric Co. submitted proposal to Council offering to sell entire rights and holdings on Thornapple River to city for $100,000; plans to build a dam and transmission line to Grand Rapids.

Minn., Victoria—Waconia Light and Power Co. has been granted a franchise to install a transmission line.

Mo., Springfield—City to vote Feb. 20 on $400,000 bonds to build an electric-light plant.

N. H., Portsmouth—(Official)—Bureau of Supplies and Accounts, Navy Department, Washington, D. C., receiving bids for 1,200 boiler tubes under Schedule No. 516, for Navy Yard, Portsmouth.

N. J., Newark—The American Synthetic Dyes, Inc., will construct three auxiliary boiler plants at its factory on Avenue R; also a new two-story absorption furnace for fumes.

N. J., Newark—Public Service Electric Co. sold $3,000,000 bonds to extend and improve power plants and systems.

N. Y., Far Rockaway—Queens Borough Gas and Electric Co. plans to construct a power station at Clinton St. About $90,000.

N. C., Durham—Durham Traction Co. plans an expenditure of $30,000 to improve its power plant.

N. D., Esmond—Council plans to construct an electric-light plant.

N. D., Warwick—H. Johnson has made plans for an electric-light plant.

N. S., Middleton—City plans to construct a transmission line from Nictau to Middleton. About $37,000.

Ohio, Republic—Town voted in favor of $10,000 to install an electric-light plant.

Okla., New Wilson—City to vote Jan. 5 on $10,000 bonds to improve electric-light plant.

Okla., Ringling—City will soon vote on $25,000 bonds to construct an electric-light system. Mackintosh-Walton Co., 1023 State Bank Building, engineer.

Ont., Black River—The Pembroke Electric Light Co. is having plans prepared for a power house. About $7,000.

Ont., Brigden—Council plans to construct a hydro-electric system.

Ont., Embro—West Zorra Township Council plans to extend the hydro-electric system. L. Murray, clerk.

Ont., Stratford—Board of Public Utilities Commission let the contract for a substation to R. Marson, 378 Nelson St. About $9,695.

Penn., Chester—The Consumers' Ice Co. plans to construct an addition to its plant; also install water-tube boilers, engines and ice machine.

Penn., Philadelphia—The Philadelphia Rapid Transit Co. plans to construct additions and alterations to its power plant on Kensington Ave.

R. I., Newport—(Official)—Bureau of Yards and Docks, Navy Department, Washington, D. C., receiving bids for 65 nickel valves under Schedule No. 536, for Norfolk Navy Yard.

S. C., Charleston—(Official)—Bureau of Yards and Docks, Navy Department, Washington, D. C., receiving bids for four flange gate valves under Schedule No. 516, for Charleston Navy Yard.

S. C., Charleston—(Official)—Bureau of Yards and Docks, Navy Department, Washington, D. C., receiving bids for four flange gate valves and 24 flange hose valves under Schedule No. 516, for Charleston Navy Yard.

Tex., Bowie—City voted in favor of purchasing an electric-light plant; also plans extending and improving same.

Tex., Houston—The Baptist Sanitarium plans to construct a power plant. About $8,000.

Va., Norfolk—(Official)—Bureau of Supplies and Accounts, Navy Department, Washington, D. C., receiving bids for 10,000 lb. of brass tubing under Schedule No. 516, for Navy Yard, Norfolk.

Wash., Bremerton—(Official)—Bureau of Supplies and Accounts, Navy Department, Washington, D. C., receiving bids for 1,000 ft. aluminum voice tubing, 96 galvanized, malleable-iron unions, composition, angle and globe valves, composition gate valves, under Schedules Nos. 521 and 525, for Puget Sound Navy Yard.

Wash., Seattle—Council has authorized the construction of a steam-electric plant on Lake Union. About $390,000.

Wis., Knapp—City plans to install an electric-light plant. A. S. Wells, secretary, Wells Electric Construction Co., New Richmond, is interested.

Prices—Materials and Supplies

Conduit—Following are net prices in cents per ft. in New York in 1,000-ft. lots:

In.	Rigid	Flexible	In.	Rigid	Flexible
½	5.18	6.80	1½	16.22	23.80
¾	6.78	8.84	2	21.83	30.60
1	10.03	14 28	2½	34.51	35.36
1¼	13.57	17 68			

Standard lengths rigid, 10 ft. Standard lengths flexible, ½ in., 100 ft. Standard lengths flexible, ¾ to 2 in., 50 ft

Locknuts and Bushings—Following are net prices in New York in standard packages, which are: ½ in., 1,000; ¾ to 1¼ in., 100; 1½ to 2 in., 50:

In.	Locknuts Per 100	Bushings Per 100	Flexible Conduit Box Connections Per 100
½	$1.02	$1.68	$5.62
¾	1.75	4.00	7.12
1	3.00	6.15	10.50
1¼	5.00	8.20	15.00
1½	7.50	10 25	22 50
2	10.00	16.40	30 00
2½	12.30	24.60	67.50

Conduit Couplings—Following are net prices in New York in standard packages:

In.	Per 100 Rigid	Per 100 Flexible	In	Per 100 Rigid	Per 100 Flexible
½	$4.69	$9 37	1½	$15.12	$22.50
¾	6.70	12.00	2	20.16	30 00
1	8.71	15.75	2½	28.80	45.00
1¼	12 24	15.75			

Armored Cables and Box Connectors—Following are net prices in New York per 1,000 ft. cable and standard package of 100 box connectors in single and double strip:

Wire Gage	Twin Conductor Cable	Twin Conductor Connectors	Three Conductor Cable	Three Conductor Connectors
14	$65.00	$3.75	$106.26	$3.75
12	103.95	3.75	130.90	3.75
10	142.45	3.75	180.95	3.75
8	180.95	3.75	250.25	3.75
6	284.90	4 75	363 44	7.00
4	442.75	7.00	.....	....

Standard lengths per coil—Nos. 14 to 10, 150@250 ft.; Nos. 8 to 4, 100@150 ft.

Porcelain Cleats—Following are net prices in New York in packages of 250:

Two- and three-wire, wire ½ in. from surface, for Nos 12 and 14 wire..... $12,00 per 1,000

Porcelain Split Knobs—Following are net prices in New York in packages of 500:

	Price per 1,000
No. 10, 8 or 6, 1¾ in. high, 1¼ in. diam	$22.50
No 12 and smaller, 1¾ in high, 1⅛ in. diam	11.00

Knife Switches—Following are net prices each in New York for knife switches mounted on slate base, front connected, punched clip type:

	30 Amp.	60 Amp.	100 Amp.	200 Amp.
Double pole, single throw, fuseless	$0.76	$0.88	$1.80	$3.24
Double pole, single throw, fused	.76	1.30	2 63	4.86
Double pole, double throw, fuseless	1.22	1.44	3.24	5.40
Double pole, double throw, fused	1.58	2.45	5.33	9.36
Triple pole, single throw, fuseless	1.15	1 32	2.71	4.87
Triple pole, single throw, fused	1.15	1.94	3.96	7.30
Triple pole, double throw, fuseless	1 91	2.23	4.97	8.35
Triple pole, double throw, fused	2.53	3.92	8.52	14.98

Lots $25 and more, list.

Fuses—Following are net prices in New York on standard packages:

	0-30	31-60	61-100	110-200	225-400
Fuse plugs, per 100	$4 20	....	....	....	....
Enclosed fuses, each	.1275	$0.18	$0.46	$1.02	$1.84

Standard package fuse plugs, 500; cartridge 3-60, 100; 65-100, 50; 110-400, 25. Fuse plugs less than package, 5c. each.

Sockets—Following are net prices per 100 in New York for standard packages:

	Package	Key	Keyless	Pull Chain
⅛-in. cap	500	$20 75	$18.80	$37.70
⅜-in. cap	250	28.08	25 92	47.52
Pendant cap ⅛-in.	250	20.75	18.80	37.70
Less than package in ⅛ and pendant and more than 25, each		.22	.20	.40

Copper Wire—Following are prices in New York for rubber-covered wire in standard quantities of 1,000 ft.:

	Dec. 27, 1916		
No.	Single Braid	Double Braid	Duplex
14	$13.50	$14.90	$25.56
12	17.70	19 70	38.65
10	24.30	26.75	52.70
8	34.50	37.12	73.60
6	54.05	58.55	....
5	72.10	77.60	....
4	48.80	92.40	....
3	104.10	110.00	....
2	125.00	132 00	....
1	162.00	170.50	....
0	223.00	223 00	....
00	267.50	267 50	....
000	328.00	328.00	....
0000	403.50	403.50	....

Lamps—Below are present quotations on Mazda B lamps in less than standard package quantities:

	Straight-Side Bulbs				Pear-Shape Bulbs		
Watts	Plain	Frosted	No. in Package	Watts	Clear	Frosted	No. in Package
10	$0.27	$0.30	100	100	$1.00	$1.05	24
15	.27	.30	100	300	3.00	3.10	24
25	.27	.30	100	500	4.50	4.65	12
40	.28	.31	100	750	6.00	6.25	8
60	.36	.40	100	1,000	7 00	7.25	8

Standard package quantities are 10% from above prices. Yearly contracts ranging from $150 up allow a discount of 17% from list, with corresponding discounts for larger contracts.

Cut Outs—Following are net prices in New York for standard package quantities:

	Packages	Edison Plug 0-30	Cartridge Fuse 0-30	Cartridge Fuse 31-60	Cartridge Fuse 61-100
Double pole, main line	50	$0.165	$0.3025	$0.77	$1.54
Triple pole, main line	50	.242	.44	1.10	2.20
Double pole, single branch	50	.176	.385	.965	...
Triple pole, single branch	50	.297	.7425	1.65	...
Double pole, double branch	25	.341	.715	1.925	...
Triple pole, double branch	25	.495	1.2375	3.30	...
Three- to two-wire, double branch	25	.352	.825	2.31	...

Metal Moulding Base and Capping—Following are net prices in New York for standard package. Standard package, 100 ft.; standard length, 8 ft. 4 in.:

100 ft. ..... $5.18 1,000 ft. $41.60

Wooden Moulding—Following are net prices in New York for standard packages of 100 ft. painted, for wire Nos. 14 and 12:

Two-wire.....$28 per 1,000 ft. Three-wire.....$31 per 1,000 ft.

MISCELLANEOUS

Hose—

	Fire 50-Ft. Lengths
Underwriters', 2½-in.	55@60c. per ft.
Common, 2½-in	60% from list

	Air First Grade	Second Grade	Third Grade
¾-in., per ft.	$0.45	$0.25	$0.18

Steam—Discounts from list

First grade..... 33⅓% Second grade..... 40% Third grade..... 50%

Rubber Belting—The following discounts from list apply to transmission rubber and duck belting:

Competition ..... 60% Best grade 30%
Standard 50%

Leather Belting—Present discounts from list in New York are as follows:

Medium grade..... 40—5% Heavy grade..... 35—5%

Packing—Below are prices per pound, New York City:

Asbestos

Valve and Stuffing Box	Twisted plain, 25-lb. cartons	$0 70
	Twisted graphite, 25-lb cartons	.80
	Braided plain, 25-lb. cartons	.90
	Braided graphite, 25-lb. cartons	1 00
Asbestos wick in balls, ¼, ½, 1 lb., 25- and 50-lb. cartons		.75
Rubber asbestos, compressed sheet, medium grade, about		.80

Steam

Following in 25- and 50-lb. cartons:

First grade ..... $0.75 Second grade $0.50

Rubber and Duck

Higher grade ..... $0.40 Cold water $0.25

Piston

Asbestos, duck and rubber... $1.25 Rubber and duck..... $0.90
Flax first grade..... .85

Greases—Price in New York in cents per pound for barrel lots:

Cup ..... 5@7c. Axle ..... 3@4c.
Fiber or sponge..... 5@7c. Gear ..... 4@5c.
Transmission ..... 5@7c. Car journal (S & F)..... 6½c.

Fuel Oil—Price in cents per gal. at Eastern terminals in bbl. lots:

Domestic light, 22-26 Baumé..... 4¼@5
Mexican heavy, 12-14 Baumé..... 5¼@5¾

Eastern terminals are Boston, Providence, Bayonne, Philadelphia, Baltimore and Norfolk.

Cold Drawn Steel Shafting—From warehouse to consumers requiring fair-size lots, the following quotations hold:

	Dec 27, 1916	Six Months Ago
New York	List plus 20%	List plus 20%
Cleveland	List plus 20%	List plus 20%
Chicago	List plus 5%	List plus 10%

Fire Brick—Quotations on the different kinds are as follows, f o b. works, eastern Pennsylvania:

Silica brick, per 1,000	$40.00@ 50.00
Fire clay brick, per 1,000	35.00@ 40.00
Magnesia brick, per net ton	135.00@140.00
Chrome brick, per net ton	125.00@135.00
Deadburned magnesite brick, per net ton	85.00@ 90.00
Special furnace chrome brick, per net ton	60.00@ 70.00

Standard size, 9x4½x2½ in. The second quality is $4 to $5 cheaper per ton.